POWER PLANT ENGINEERING

Established Over 31 Years

VOL. XXXI CHICAGO, MAY 15, 1927 No. 10

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Published on the 1st and 15th of each Month by the

Technical Publishing Co., 53 West Jackson Blvd., Chicago

New York Office, 150 Nassau Street

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents. Copyright 1927, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations

Circulation of this Issue 23,000

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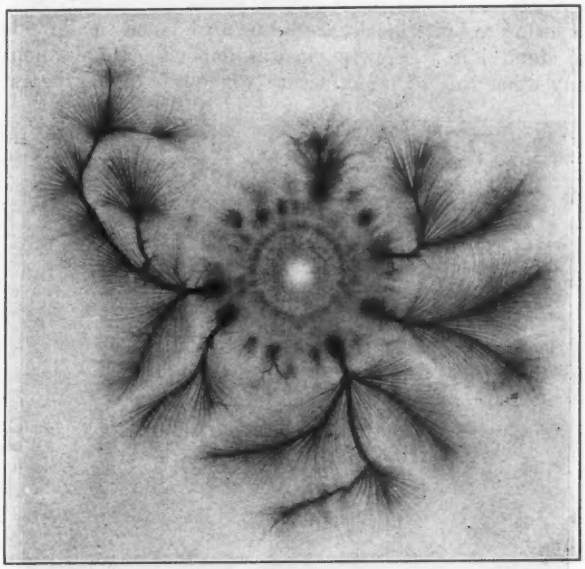


The Autograph of a Thunderbolt

GRAPHOLOGISTS tell us that our character is reflected in our handwriting and that they have only to glance at a specimen of our writing to learn all about us. Certain little peculiarities in the way we form letters, how we dot i's and cross t's, or how we slope the lines reveal our inherent characteristics. In fact, if all the graphologists say is true, then a letter written in longhand is little less than a mirror to one's soul. We don't altogether relish the thought and our advice is to use the typewriter, especially when writing to graphologists.

We are not alone, however, in this inability to conceal our character in our writing. Even such an inhuman thing as a thunderbolt is subject to this failing. Direct your attention to the strange figure shown at the top of this column. Funny looking thing, isn't it? Well, that is nothing more than the handwriting of a thunderbolt—its autograph, in fact. And strange to say, this odd shaped figure with its feathery branches tells the whole story of the lightning surge that produced it. It reveals its magnitude, its shape, its duration, its polarity—everything the electrical engineer wants to know about it.

The principles employed in obtaining the thunderbolt's autograph are over 150 yr. old, but it is only within the past few years that we have been able to apply the laws of graphology and to lay bare the lightning stroke's soul. The article on page 570 tells how this was accomplished.

Operating Problems at the Pabst Corporation

By Means of Adequate Records and Care in Operating Existing Equipment, Famous Brewery Effectively Meets New Conditions Created by Prohibition

WHEN THE PABST CORP. at Milwaukee, Wis., after the passage of the 18th Amendment to the Constitution, found itself faced with the complete destruction of the market to which its entire organization and equipment had been specially adapted, it immediately took steps to meet the new condition. It was unthinkable, of course, from a business point of view, that this enormous plant costing millions of dollars and covering five city blocks should be abandoned or allowed to stand idle. Likewise, it was impossible to develop any other line of manufacture which would, for years

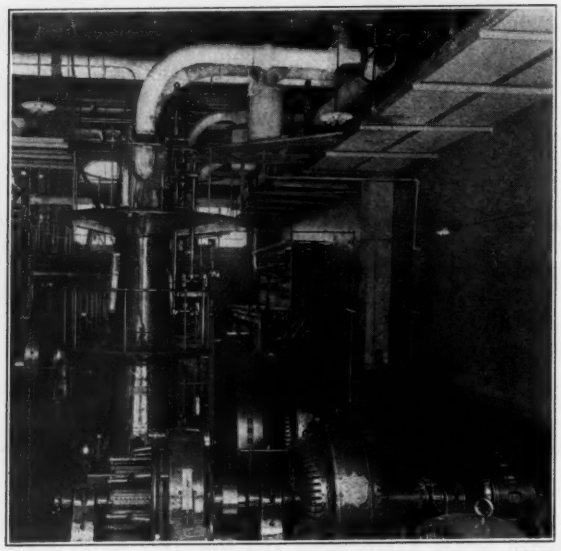


FIG. 3. VERTICAL CORLISS ENGINES DRIVE A.C. GENERATORS, THE M-G SETS IN THE FOREGROUND SUPPLYING D.C. FOR LIGHTING AND EXCITATION

to come, utilize fully this great plant with its acres of floor space and its power plant, large enough to supply a small city.

The immediate problem was to salvage as much as possible out of the wreck. The large power plant and the substantial buildings suggested as a first step the creation of a "Central Manufacturing District." To this end an active campaign was begun to find tenants who would require electricity for light and power and where possible, live steam and even refrigeration for manufacturing. Today almost sixty per cent of the floor space is leased to some 30 industrial concerns, some of whom occupy entire buildings. Among these tenants are two manufacturers of dairy products, several knitting companies, printing and paper product manufacturers and manufacturers of machinery and electrical apparatus.

As a second step, the Pabst Corp. began the manufacture of soft drinks and of malt syrup, thus utilizing some of its equipment adapted to this class of manufacture. Later it began the manufacture of loaf and package cheese. This department now uses the refrigerated storage cellars for the "curing" of cheese. Hundreds of carloads of cheese are now "cured" in these cellars at a constant temperature for a period of from 8 to 10 mos. before being used.

Economical operation was of primary importance in making the new Pabst enterprises a success. The "Central Manufacturing District" had to sell its "Utility Service" at prices which would attract tenants, which in turn required the utmost economy in operation. The power plant equipment was good, but not of the most modern type. However, it was believed that this handicap could be overcome by careful, scientific operation and the results have fully justified this conclusion.

During the first few years the results of power plant operation under the new conditions were unsatisfactory.

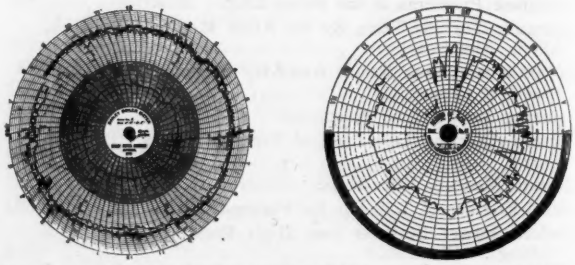


FIG. 1. A—BOILER METER CHART FROM NO. 6 BOILER SHOWING STEAM AND AIR FLOW WITH FLUE GAS TEMPERATURE ON INNER CHART. B—TYPICAL 24-HR. CO_2 RECORD FROM NO. 5 BOILER

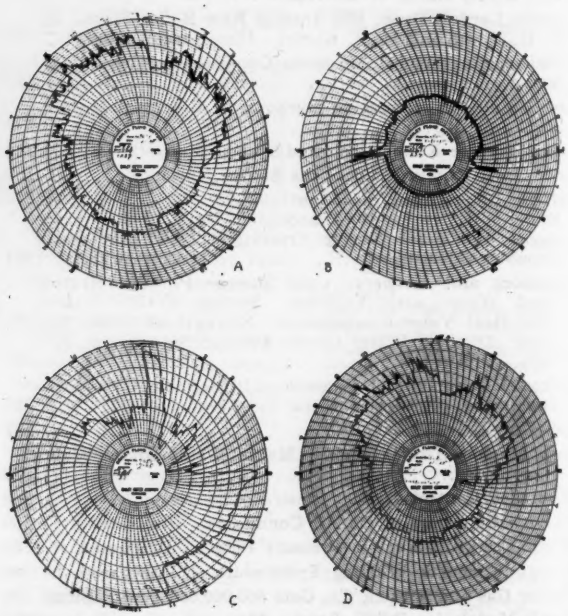


FIG. 2. TYPICAL 24-HR. RECORDS OF STEAM FLOW TO VARIOUS DEPARTMENTS. A—FLOW IN LINE ENTERING ENGINE ROOM, WHICH SUPPLIES STEAM TO ENGINES, SYRUP DEPARTMENT AND BREW HOUSE. B—STEAM TO BOILER ROOM AUXILIARIES. C—HEATING LOAD. D—FULL STEAM LOAD ON PLANT

The plant, like many similar plants, was not equipped at that time with sufficient recording instruments to keep adequate operating records; however, the records which were available indicated clearly that neither the boiler nor the engine room were operating at maximum efficiency. At that time the boilers were evaporating from six and a half to seven pounds of steam per pound of coal.

In 1923 the plant was completely equipped with such instruments as were found necessary to present a complete picture of what was going on in each step from the coal pile to the point where the steam, the electricity and the refrigeration were finally used. From that time on the improvement in operation was rapid and continuous, as is shown by the table.

	Lb. of Steam Generated	Lb. Coal Burned	Lb. Steam per Lb. Coal Used (actual)
1923....	320,117,800	42,863,570	7.46
1924....	363,170,000	40,897,000	8.88
1925....	410,956,541	44,636,840	9.22
1926....	446,333,013	48,005,430	9.29

In connection with these figures it is of interest to note that previous to 1923, run-of-mine coal, mixed with

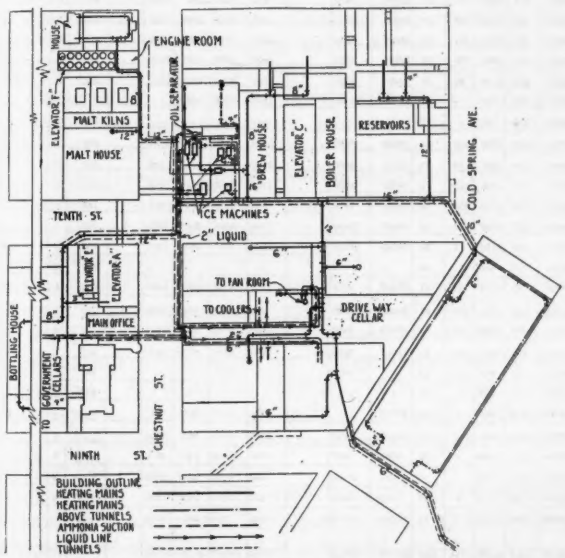


FIG. 4. PROPERTY PLAN OF PABST CORP. SHOWING HEATING MAINS AND OTHER PIPING

screenings was burned but at the end of 1923 the use of the run-of-mine coal was discontinued and Youghiogheny screenings were used exclusively. Thus the actual evaporation has been increased while using a cheaper coal.

Engine room performance has also been improved, as shown by the following tabulation, in spite of the fact that the generating units are not of the most modern type.

	Lb. Steam used by Generating Units	Kw-hr. Generated	Lb. Steam per Kw-hr.
1924....	68,590,000	1,584,580	43.2
1925....	66,646,000	1,734,088	38.2
1926....	62,107,200	1,870,840	33.1

The interesting feature of these tables is the fact that only minor changes have been made in the existing power plant equipment. The 1926 results were obtained with the same power house employes operating the same equipment as in 1923 and previous thereto, the only difference being the *method* of operation.

All that was done during that period was to obtain a true picture of what was going on, analyze the picture in minute detail and correct what was unsatisfactory. By keeping a constant vigil and correcting faults as fast as they appeared in the picture presented by the charts and records, the efficiency of the plant continued to improve until the present high level was reached.

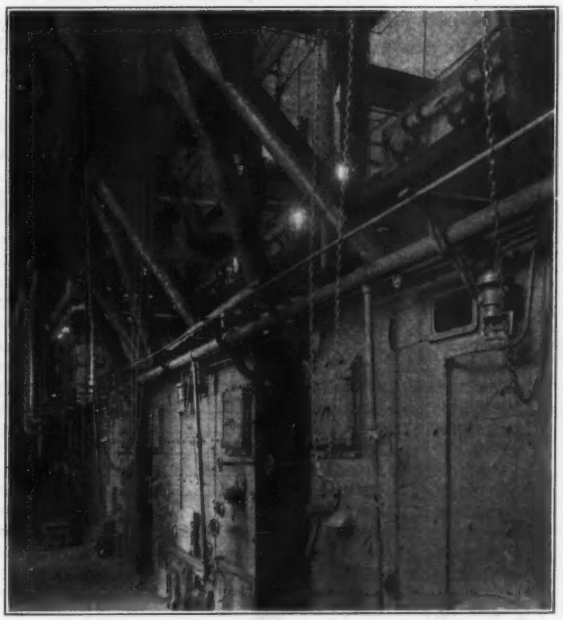


FIG. 5. FOUR OF THE BOILERS ARE FIRED BY MURPHY STOKERS

FIG. 6. FOUR OF THE EIGHT BOILERS, SHOWING TYPE E STOKERS, BOILER METERS AND ACCESSORIES

The flow meter on the main steam header which records the total steam generated and from which reading the ratio of evaporation is computed, is frequently checked by drawing the feed water for a period of 4 or 5 hr. from a 125,000-gal. underground concrete reservoir, and measuring the water used by means of a hook gage. In the fourth column of Table I is a record of "Miscellaneous Unaccounted-for Steam." This item

should more properly be called "Unmetered Steam" since it includes steam used for certain purposes which has not been metered, although it is known where this steam goes. The reader, therefore, should consider that most of this steam, about three million pounds for December, 1926, is used and not wasted.

Coal measurements are taken by the week, which thus becomes the unit for comparison of performance. Coal is purchased from a local company which receives it by water. It is delivered to the Pabst plant every day in varying amounts, as shown in Table I, but is stored only in the boiler house bunkers, no outside storage being provided. Daily coal deliveries, however, do not give the amount of coal burned that day. Instead, on each Saturday afternoon, the coal bunkers are filled to the same level to which they were filled the Saturday before. The records of the purchasing department thus show the amount used during the week.

To some this may seem a crude way of determining coal consumption and it would be if only one or two weeks were taken as the unit. Over a number of weeks, however, and especially over a year, it is quite accurate. Almost invariably an unusually good ratio for one week is followed or preceded by an equally poor ratio, which means that when the operators thought they had the bunker filled to the proper level, they overestimated or underestimated by a few tons. These few tons of "personal error" affect the week slightly but, when spread out over four weeks, the error is negligible and over 52 weeks is infinitesimal.

For the steam supply to various tenants and to the various Pabst manufacturing departments, steam flow meters and condensate meters record the amounts used, the condensate meters being read weekly. Examination of the tables and the property plan will show the variety of the services rendered by the power plant.

In the making of its own products, the Pabst Corp. needs heating steam, process steam, electric power for lighting and motors, refrigeration and a considerable amount of compressed air. This is all produced by the power plant. Table I shows the amounts of steam supplied for all the above services for December, 1926.

The steam heating system for the entire group of buildings is partly vacuum and partly gravity system. Exhaust steam is the primary source of supply and this is supplemented by live steam as required, supplied through a reducing pressure valve. Formerly, the system was operated at from four to five pounds pressure, depending on weather conditions. By a series of systematic tests of loss of pressure throughout the distributing system during severe cold weather, the faults were located and corrected so that today the maximum pressure in zero weather is only three pounds and this pressure is further reduced in milder weather.

To insure sufficient pressure for good circulation at the farthest ends of the system at all times, regardless of the steam demand, the pressure at the power house is maintained in accordance with the chart shown in Fig. 7. A copy of this chart is posted in the engine room above the recording pressure gage on the heating main. The operator notes the outside temperature and adjusts the back pressure as called for by the chart, varying the pressure as the outside temperature varies.

On Sundays one of the large generating units floats

TABLE I. SUMMARY OF OPERATING DATA FOR DECEMBER, 1926, SHOWING EVAPORATION, ELECTRICAL DATA AND STEAM SUPPLIED TO VARIOUS DEPARTMENTS

DATE	LBS. STEAM GENERATED	LBS. COAL DELIVERED	LBS. STM PER LB. COAL USED	MISC. UNACCOUNTED FOR STM	TOTAL WATER USED	HOT WATER USED	TOTAL K.W.H.	K.W.H. PURCH.	K.W.H. GENERATED	LBS. STM PER K.W.H.	LBS. COND. USED	LIVE STM FOR HEAT	BOILER ROOM AUSIL.	ELECTRICAL ENGINES	REFRIG.	BREW HSE.	EXTRACT	BOTTLE HSE.	EVERWEAR	SUNSHINE DAIRY	CHECKER GAS	WESTERN RAWHIDE	BLUE VALLEY	MASTER LOCK	FINDLEY	AV. FEED WATER TEMP.				
1	1226339	156250		120941	59700		6600		6600			294000	96000	159000	197	1500	148	62	29000	7400		1000	4800	1958	2000	212°				
2	1329058	133500		122128	64500		7000		7000			324000	94400	164500	214	1545	259	60	24000	6800		600	4800	2083	1100	212°	8	-	-	8
3	1178811	110600		105880	69300		6900		6900			219000	91200	164500	209	1578	180	62	24000	6200		1000	7800	2081	1800	212°	4	2	-	6
4	1043543	113050	9.23	31780	34800		3400		3400			256000	90400	164500	174	1065	107	63	18000	16200		1100	8000	2865	200	210°	-	4	-	5
5	688405	-		99805	20400	68397	1000		1000			359000	80800	68500	109	885	-	55	-	-		-	-	-	-	210°	2	-	-	2
6	1317966	201200		101002	51300		6900		6900			327000	97600	201600	167	1905	137	62	22000	7400		900	7500	2064	2000	210°	-	-	-	7
7	1288957	178650		94739	49400		7100		7100			287000	95600	208000	169	1860	153	65	20000	7800		1200	1000	1998	2400	210°	-	-	-	-
8	1305133	132850		79002	50100		6800		6800		EX. 1892,600 LIVE 37,000	259000	92800	146000	210	1680	121	69	22000	7800		1100	5780	2131	2300	212°	10	2	2	3
9	1404738	134050		139438	66100		7000		7000			244000	97200	172000	197	2490	206	63	22000	8600		1100	6750	2197	2200	212°	-	-	-	-
10	1090700	186580		138936	51200		6700		6700			220000	90400	132000	208	1170	98	70	18000	7800		1100	6000	2366	2100	212°	2	-	-	2
11	910430	92250	9.01	64158	34400	38620	3200		3200			309000	61600	101000	147	900	-	59	19000	17000		1100	7500	1965	-		2	-	-	2
12	612909	-		106809	26300		1100		1100			307000	79400	64000	131	840	-	52	-	-		-	-	-	-	207°	-	-	-	4
13	1330985	203900		138384	63400		6900		6900			260000	94800	137000	201	2780	138	60	19000	7800		1100	5800	2221	1700	209°	7	2	-	10
14	1527513	177650		146616	92100		7100		7100		EX. 1661,900 LIVE 12,100	253000	106800	299000	179	2520	99	72	22000	8600		1000	7250	2297	2200	210°	8	2	-	12
15	1366603	182800		144539	61400		7000		7000			406000	107800	195000	158	2430	149	71	19000	9800		1100	6900	2364	2200	210°	2	-	-	-
16	1391887	188450		123820	48400		6400		6400			383000	101200	155000	176	2370	136	74	22000	9800		900	7250	2367	500	208°	3	1	-	5
17	1199959	186450		137692	40300		5500		5500			363000	97200	143000	157	1140	73	77	20000	10400		1200	6500	2467	2200	208°	2	-	-	2
18	1029066	100300	9.06	109186	28300		3000		3000			411000	79800	70800	136	1188	6	64	18000	17200		1100	7750	1900	1300	210°	2	-	-	18
19	934028	-		129825	23100	37600	1100		1100			425000	78200	31500	136	885	-	50	-	-		-	-	-	-	210°	2	-	-	2
20	1186872	200850		140906	61800		6300		6300		EX. 2,088,300 LIVE 14,400	272000	99400	117500	193	1605	121	61	17000	9000		1100	6750	2267	2200	208°	6	3	-	12
21	1460866	161000		145333	91100		7300		7300			243000	97600	146000	203	2790	253	64	16000	8800		900	8250	2338	1900	210°	-	-	-	5
22	1441631	182000		149984	113800		7200		7200			261000	96800	180600	204	2715	200	64	17000	9400		1000	6750	2467	2100	210°	5	3	-	-
23	1272304	148850		108094	99300		7000		7000			203000	92000	132000	204	1920	200	61	19000	8600		1800	7000	3000	1400	212°	2	-	-	5
24	960256	91700	9.11	126689	37800		4000		4000			295000	80000	90500	170	975	-	53	-	7400		-	5800	-	-	212°	-	-	-	3
25	916423	-		139823	24600		1000		1000			400000	77600	29800	122	918	-	57	-	-		-	-	-	-	212°	8	-	-	-
26	683643	-		123410	26700	12642	1100		1100			364000	73200	34000	123	900	-	60	17000	-		1500	2500	1833	-	211°	-	6	-	6
27	1009705	166000		138672	39700		4100		4100		EX. 1792,800 LIVE 14,200	299000	68000	127000	165	900	-	67	14000	1000		1000	6000	3438	2500	213°	-	-	-	2
28	992902	161650		152036	37500		3800		3800			275000	61200	130500	163	855	-	68	8000	3800		1000	10250	2387	2500	215°	4	3	-	8
29	1014108	134950		106311	36800		5400		5400			343000	82400	144500	152	855	-	78	7000	11000		800	7500	2697	1900	215°	3	-	-	3
30	1022569	90300		136672	37700		4800		4800			324000	68000	141500	156	975	-	77	8000	10300		600	6500	2597	2300	215°	2	-	-	6
31	934943	121380	8.99	68012	29800		3400		3400			315000	60400	116000	148	930	-	61	18000	18600		1200	7500	2430	1300	215°	-	-	-	-
TOTAL	33704908	3926500		3771013 FROM 3478015	1552800		155600		155600			9472000	2773600	4174000	5364	46600	2754	1991	448000	345200		27200	175250	61192	40750		71	32	3	157

on the line, so that the steam rate per kw-hr. for the plant will be much larger on this day than on the others.

Methods of distributing the time of the power plant operators are interesting. Each man works for 13 consecutive days and then has two days off. When he returns he takes the next shift to the one on which he last worked. Thus his "time off" rotates throughout the days of the week and his shift rotates 8 hr. every two weeks.

Boilers are located in one building and the engines, service pumps and air and ammonia compressors in another.

In the boiler house are installed eight Edge Moor cross-drum water-tube boilers of 4100 sq. ft. heating surface each, designed for operation at 165 lb. gage pressure. Four of these are fired by Combustion Engineering Corp. Type E stokers, Fig. 6, and four by Murphy stokers, Fig. 5, the latter being driven by a Murphy stoker engine with a duplicate engine in reserve. Stokers and boiler settings are arranged so that the boilers can be operated under normal load conditions at from 150 to 200 per cent of rating. The average CO_2 is about 11 per cent as shown by a typical chart in Fig. 1B, although for long periods it will go as high as 12 and even 13 per cent. Uehling CO_2 recorders are used and checked frequently by an Orsat. At 170 per cent of rating the stack temperature averages 540 deg.

These boilers are each equipped with two 4-in. Ashton safety valves, Reliance water columns with low water alarm, S-C feed water regulators, Diamond soot blowers, Homestead blowoff valves, Golden-Anderson non-return valves and Ashton pressure gages. Bailey boiler meters give a record of steam and air flow and stack temperature as shown in the chart, Fig. 1A.

To supply forced draft for the Type E stokers, two Clarage fans are installed, each rated at 36,000 c.f.m., driven by 7 by 7-in. Clarage fan engines at 300 r.p.m. These fans are controlled by Ruggles-Klingemann fan regulators. A radial tile chimney, built by The Heine Chimney Co., 227 ft. high and 12 ft. inside diameter, furnishes natural draft for the other units and carries off flue gas from all boilers.

As noted above, the coal used is Youghiogheny screenings. Analysis of this coal is made at least once a month and the following is a typical report on it.

	As Received per cent	Dry per cent
Moisture	4.94	...
Ash	8.69	9.14
Volatile	31.88	33.54
Fixed Carbon	54.49	57.32
	100.00	100.00
B.t.u.	13,028	13,705
Sulphur	0.85%	0.89%

Coal is brought to the plant by truck and unloaded into a hopper which feeds into a Link-Belt pivoted bucket conveyor which takes it to the bunkers above the boilers, six of them holding 60 t. apiece and two holding 80 t. each.

For supplying feed water to the boilers, all condensate from the plant is brought back to a Hoppes steel plate open type feed water heater of 100,000 lb. an hour capacity, located on a gallery in the center of the boiler room, just above the feed pumps. This heater delivers water at an average temperature of 210-212 deg. Makeup water is introduced here, taken from the plant water system at 75 lb. pressure, this system in turn taking water from the city mains through a booster pump. Three steam-driven, reciprocating Blake & Knowles (Worthington) pumps, each 15 by 8 by 15 in. of the outside end packed type, supply feed water to the boilers.

Bailey meters are installed on each boiler and there is a Bailey steam flow meter on the main steam header and one on the header to the boiler room auxiliaries. Records of various temperatures of flue gas and the like

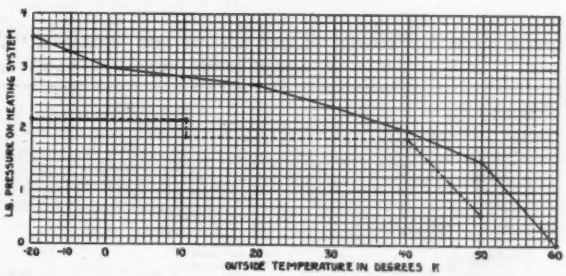


FIG. 7. PRESSURE TO BE CARRIED ON HEATING SYSTEM FOR VARIOUS OUTSIDE TEMPERATURES. WORKING DAYS, 6 A. M. TO 6 P. M. ————; SUNDAYS, HOLIDAYS AND WORKING DAYS, 6 P. M TO 6 A. M. ————

are kept by Foxboro recording pyrometers. Temperature of water leaving the feedwater heater is recorded by a Bristol instrument.

Steam is sent to the engine room in another building through a loop header. Here are installed three Allis-Chalmers vertical Corliss engines as shown in Fig. 3. Two of these are cross-compound units, each 18 by 30 by 36 in., running at 125 r.p.m. and driving a 400-kw., 440-v., 3-phase, 25-cycle Bullock generator. The other is a 20 by 36-in. vertical simple Corliss driving a 300-kw., 440-v., 3-phase, 25-cycle generator at 125 r.p.m. There is also installed a 16½ by 21-in. Buckeye vertical engine driving an 800-amp., 120-v. Bullock d.c. generator at 200 r.p.m. All these units are non-condensing, exhausting into a low pressure header to supply steam for the heating system, for hot water and for manufacturing processes. Throttle pressure on all units is 150 lb.

Two Bullock motor-generator sets are installed, each consisting of a synchronous motor with direct-connected starting motor, Fig. 3, driving a 1000-amp., 120-v. d.c. generator. These m-g sets supply excitation for the alternators and their motors aid in correcting power factor. They also supply direct current for the plant lighting system in connection with the engine-driven d.c. generator. All motor circuits throughout the factory building are 440-v. a.c., and if a tenant needs d.c. for any of his process motors he transforms it with a motor-generator set.

Electric power is distributed through a white marble switchboard shown in Fig. 3, on which are mounted Westinghouse oil switches and meters for all the alternating current circuits. For the excitation circuits and lighting circuits, General Electric totalizing meters are

installed. An Allis-Chalmers slate switchboard handles the direct-current distribution to the plant.

Refrigeration is furnished by three De La Vergne refrigerating machines. There are two machines of 300 t. refrigerating capacity each; their steam ends are 28-in. by 52-in. by 40-in. cross-compound engines driving 20-in. by 40-in. twin double acting compressor cylinders. The third unit consists of a simple engine with 26-in. by 32-in. steam cylinder driving a 16-in. by 32-in. twin single acting compressor.

Both filtered and unfiltered compressed air is used throughout the plant. All air which comes in contact with food products is filtered through cotton filters and delivered by a 14-in. by 16-in. by 18-in. twin, steam-driven compressor at a pressure of 30 lb. Air at 100 lb. pressure is used for "blowing" a 1500-ft. well and air from the same system is used for charging the "dry sections" of the sprinkler system, as well as for operating small portable pumps and for other similar services. This high pressure unfiltered air is furnished by a Pennsylvania 10 by 12 by 10-in. crank-and-flywheel type compressor with a Westinghouse 140-c.f.m. locomotive type, compound air compressor in reserve.

Water for manufacturing and domestic purposes is taken from the city mains and delivered to the plant distribution system at a pressure of 75 lb. by a steam-driven, Nordberg horizontal pumping engine with a capacity of 2,000,000 gal. a day with a Blake & Knowles horizontal pumping engine 12 by 18½ by 12 in. and 14 by 12 in. held in reserve.

Water for the condensers in the syrup department is cooled in a cooling tower on the roof of one of the buildings; this water is circulated by an Allis-Chalmers horizontal, double-opposed compound, water works pump, rated at 4,000,000 gal. a day.

The fire pump is installed in a separate room and is a Knowles 20 by 12 by 12-in. duplex with a capacity of 1500 g.p.m. It draws its supply from a 250,000 gal. underground concrete reservoir and discharges to the sprinkler mains, connected with a 100,000-gal. sprinkler tank 160 ft. high.

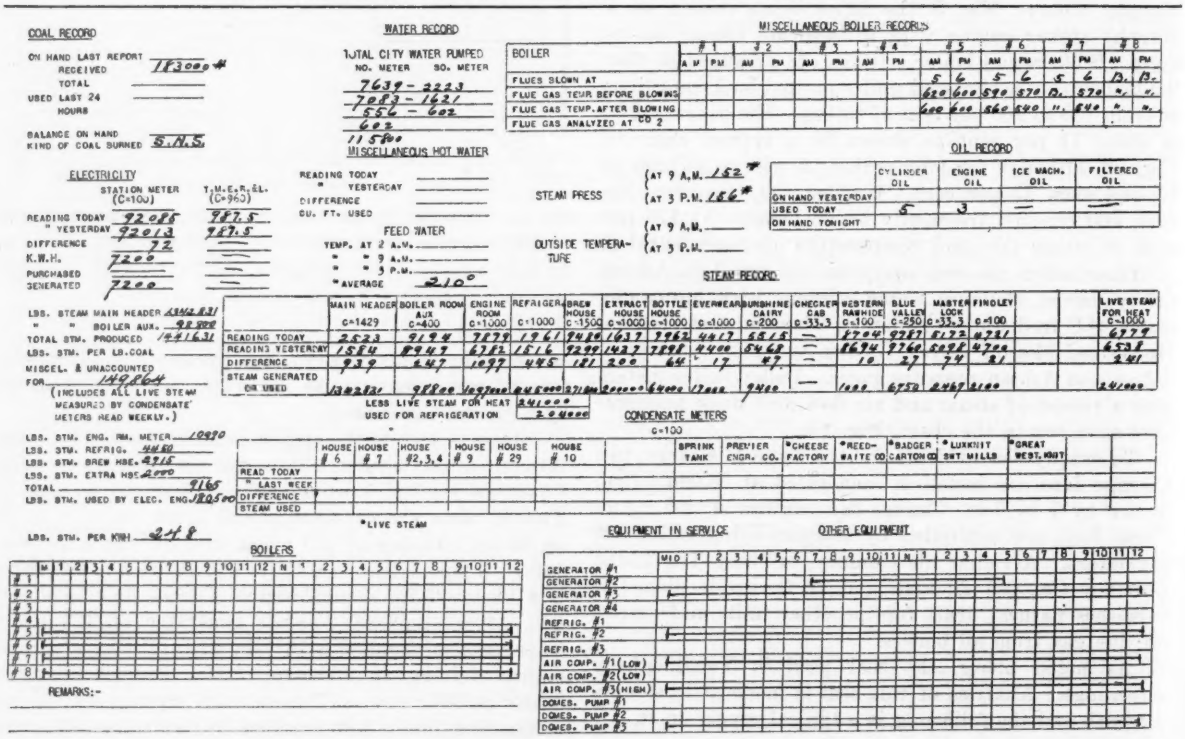
Three steam-driven dry vacuum pumps are installed for the evaporators and condensers of the syrup department. Each unit is of 525 c.f.m displacement, one being an Alberger and the other two Buffalo Foundry & Machine Co., one unit acting a spare.

Large amounts of steam, about 25,000 lb. an hour, are used for cooking in the brew house and this is supplied from the main steam header at 35 lb. through a Boylston reducing valve. The syrup department takes about the same amount at 10 lb. pressure through another Boylston reducing valve. Some of the older pumps take steam at 100 lb.; this is supplied through a 6-in. Foster reducing valve.

Live steam for heating is obtained through a Mason reducing valve. On a cold day, or when the engines are shut down, this live steam heating load may go to 30,000 lb. an hour.

This plant furnishes a splendid example of the improvement in results that can often be obtained by careful operation of the equipment at hand. This work has all been done under the direct supervision of Fred J. Postel, assistant general manager of Pabst Corp., with John Wax as chief operating engineer. We wish to acknowledge our indebtedness to these men for data, illustrations and the most cordial co-operation.

TABLE II. DAILY POWER PLANT REPORT FOR DECEMBER 22, 1926, SHOWING HOW DAILY RECORDS ARE TAKEN FOR COMPARISON WITH PREVIOUS DAY. CONDENSATE METERS ARE READ WEEKLY


COAL RECORD
ON HAND LAST REPORT 18000#
RECEIVED
TOTAL
USED LAST 24 HOURS
BALANCE ON HAND
KIND OF COAL BURNED S.N.S.
WATER RECORD
TOTAL CITY WATER PUMPED
NO. METER SO. METER
7639 - 2223
7693 - 1621
556 - 602
6083
11500
MISCELLANEOUS HOT WATER
READING TODAY
" YESTERDAY
DIFFERENCE
CU. FT. USED
FEED WATER
TEMP. AT 2 A.M.
" " 9 A.M.
" " 3 P.M.
" AVERAGE 210°
ELECTRICITY
STATION METER (C=100)
T.M.C.R.&L. (C=960)
READING TODAY 92085 987.5
" YESTERDAY 92013 987.5
DIFFERENCE 72
K.W.H. PURCHASED 7200
K.W.H. GENERATED 7200
MISCELLANEOUS BOILER RECORDS
BOILER #1 #2 #3 #4 #5 #6 #7 #8
FLUES BLOWN AT 5 6 5 6 5 6 B. B.
FLUE GAS TEMP. BEFORE BLOWING 620 600 590 570 B. 570 " "
FLUE GAS TEMP. AFTER BLOWING 600 600 560 540 " 540 " "
FLUE GAS ANALYZED AT CO2
STEAM PRESS AT 9 A.M. 182# AT 3 P.M. 186#
OUTSIDE TEMPERATURE AT 9 A.M. AT 3 P.M.
OIL RECORD
CYLINDER OIL ENGINE OIL ICE MACH. OIL FILTERED OIL
ON HAND YESTERDAY 5 3
USED TODAY
ON HAND TONIGHT
STEAM RECORD
MAIN HEADER C=1429 BOILER ROOM AUX C=400 ENGINE ROOM C=1000 REFRIGER C=1000 BREW HOUSE C=1500 EXTRACT HOUSE C=1000 BOTTLE HOUSE C=1000 EVERWEAR C=1000 SUNSHINE DAIRY C=200 CHECKER CAB C=33.3 WESTERN RAWHIDE C=100 BLUE VALLEY C=250 MASTER LOCK C=33.3 FINDLEY C=100 LIVE STEAM FOR HEAT C=1000
READING TODAY 2523 9194 7879 1961 9486 1617 7962 4417 5565 — 8694 9760 5098 4700 6779
READING YESTERDAY 1584 8947 6782 1816 9229 1427 7898 4400 5468 — 8684 9760 5098 4700 6538
DIFFERENCE 939 247 1097 145 257 190 64 17 97 — 10 27 74 81 241
STEAM GENERATED OR USED 13022# 9800 lbs/hr 6000 2700 4000 17000 9400 1200 6750 2467 8100 24000
LESS LIVE STEAM FOR HEAT 241000
USED FOR REFRIGERATION 204000
LBS. STEAM MAIN HEADER 1342.831
" " BOILER AUX. 92.988
TOTAL STM. PRODUCED 1434.81
LBS. STM. PER LB. COAL
MISCEL. & UNACCOUNTED FOR 149864
(INCLUDES ALL LIVE STEAM MEASURED BY CONDENSATE METERS READ WEEKLY.)
LBS. STM. ENG. RM. METER 10970
LBS. STM. REFRIG. 4480
LBS. STM. BREW HSE. 4215
LBS. STM. EXTRA HSE. 2990
TOTAL 9165
LBS. STM. USED BY ELEC. ENG. 1805.00
LBS. STM. PER KWH 24.8
CONDENSATE METERS C=100
HOUSE #6 HOUSE #7 HOUSE #2,3,4 HOUSE #9 HOUSE #29 HOUSE #10 SPRINK TANK PREMIER ENGR. CO. *CHEESE FACTORY *REED-WAITE CO *BADGER CARTON CO *LUXKNIT SHT. MILLS *GREAT WEST. KNIT
READ TODAY
" LAST WEEK
DIFFERENCE
STEAM USED
*LIVE STEAM
BOILERS
#1 #2 #3 #4 #5 #6 #7 #8
REMARKS:-
EQUIPMENT IN SERVICE
OTHER EQUIPMENT
GENERATOR #1
GENERATOR #2
GENERATOR #3
GENERATOR #4
REFRIG. #1
REFRIG. #2
REFRIG. #3
AIR COMP. #1 (LOW)
AIR COMP. #2 (LOW)
AIR COMP. #3 (HIGH)
DOMES. PUMP #1
DOMES. PUMP #2
DOMES. PUMP #3

Hydraulic Turbine Tests by the Allen Method

ELECTRICAL CONDUCTIVITY OF SALT SOLUTION FORMS BASIS OF METHOD WHICH GIVES REQUIRED TEST ACCURACY WITHOUT THE USE OF COEFFICIENTS OR EMPIRICAL FORMULAS. BY C. M. ALLEN*

SALT IN SOLUTION increases the electrical conductivity of water and this fact forms the basis of the salt velocity method of water measurement. A salt solution is introduced near the upper end of the conduit and the passage of the solution across one or more pairs of electrodes, at other points in the conduit, is recorded graphically on a chart similar to the one shown in Fig. 1 by an electrical recording instrument. In

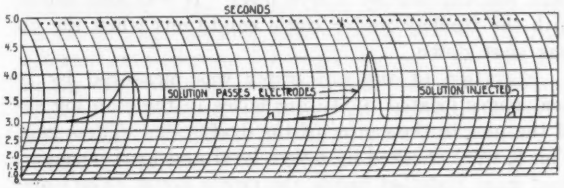


FIG. 1. DATA FROM THIS RECORDING AMMETER CHART IS USED TO CALCULATE THE WATER VELOCITY IN THE PENSTOCK

this manner the passage of the salt solution between the two points is accurately timed and the volume of the penstock between the same points being known, the discharge in cu. ft. per sec. is found by dividing the volume of the penstock in cu. ft. by the time in seconds. So far as is known, the first successful commercial test of a hydroelectric unit, using the salt velocity method of water measurement was made in 1921. The penstocks were wood stave pipe lines, 13 ft. in diameter and 1400 ft. long. Prior to this time, laboratory tests

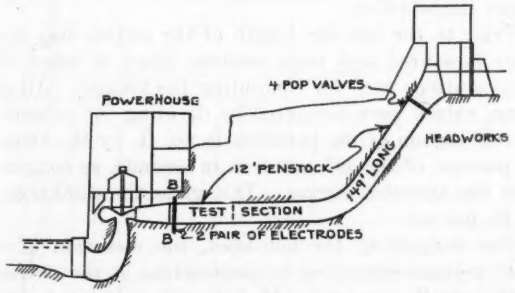


FIG. 2. THE APPARATUS USED IN TESTING NO. 3 UNIT OF THE RUMFORD FALLS POWER CO. WAS ARRANGED AS SHOWN IN THIS DIAGRAM

and investigations were carried on, and since that time both laboratory and commercial tests have been continued.

Perhaps the best way to describe the practical application of the method is by a detailed description of an actual test. In the fall of 1926 efficiency tests were made on four units for the Rumford Falls Power Co. at Rumford, Me., to determine the discharge, horsepower and efficiency of the wheels as well as the overall efficiency of the unit and to calibrate the permanent Venturi meter sections for daily measurement of the discharge of the units.

*Prof. of Hydraulic Engineering, Worcester Polytechnic Institute, Worcester, Mass.

Apparatus used, conduct of the test, method of computation and analysis of results are similar in all tests, but details vary with the size and form of the penstock so that the test of the No. 3 unit with the arrangement shown in Fig. 2 will be described. This unit has a circular concrete and steel penstock with a diameter of 12 ft. for the major portion of its length. The upper end has an enlarged entrance, and the lower end is reduced to 9 ft. 6 in. diameter at the entrance of the scroll case as shown in detail in Fig. 3. The test section was 149 ft. long and had a volume of 17,507 cu. ft.

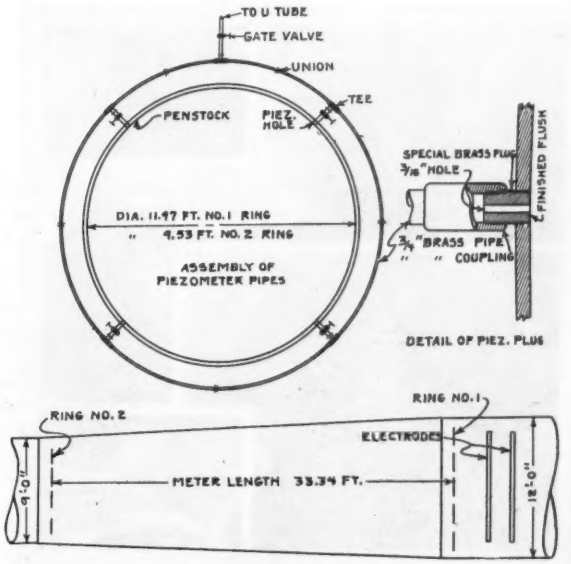


FIG. 3. A VENTURI PENSTOCK SECTION IMMEDIATELY PRECEDING THE TURBINE HAS BEEN CALIBRATED AND WILL BE USED FOR DAILY WATER MEASUREMENTS

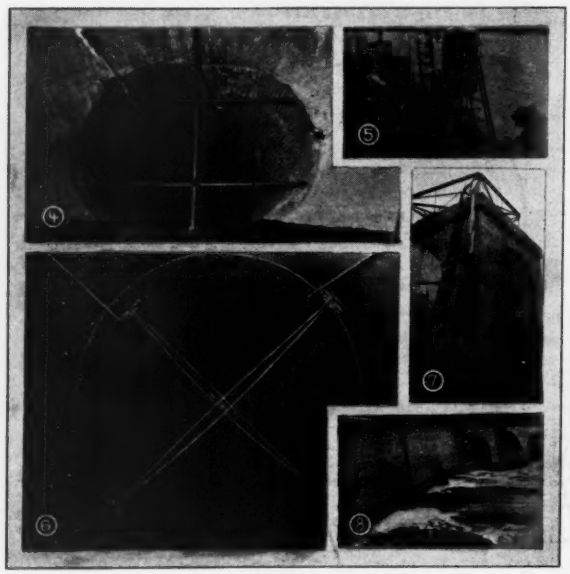
This unit is an 85 in. dia., Francis type, vertical I. P. Morris turbine, rated at 10,000 hp. at 97 ft. head and 200 r.p.m. The generator is an 8000-kv.a., 11,000-v., 3-phase, 40-cycle Westinghouse unit, which operates in parallel with two other similar units, Nos. 1 and 2, and feeds directly into the 11,000-v. transmission line. By means of suitable transformer connections, two older units, Nos. 4 and 5 at the same plant, rated 3940 kv.a., 2300 v., 3 phase, 40-cycle, 400 r.p.m., can be operated in parallel with the higher voltage machines. No. 5 unit is used for standby only and was not tested.

OPERATING CONDITIONS WERE SUCH THAT A FULL RANGE OF LOAD COULD BE OBTAINED

The major portion of the electric output of the Rumford Falls Power Co.'s plant is supplied to the Oxford Paper Co., located over a mile away. Because of the high load factor characteristics a particularly good performance for the station units results. By suitable electric adjustments among the generating units under normal commercial conditions it is possible, not only to provide a full range of output, for any generator corresponding to the different gate openings of the turbine

but to maintain it quite steadily with a power factor of approximately 100 per cent.

Generator No. 3 had been subjected to a complete acceptance test (A. I. E. E. Standard) at the factory of the manufacturer, and these data have been used as a basis to determine electrically the power delivered by the turbine shaft at given gate openings. Imbedded temperature indicators in the stator of the generator and special thermometers elsewhere gave the necessary data for a suitable temperature correction for the various electrical losses. The load was measured with calibrated test instruments both before and after the test and all switchboard and portable meters were carefully calibrated. C. T. Mainard, engineer, and Mr. Winnington, superintendent for the Rumford Falls Power Co., had charge of the installation of the test apparatus,



FIGS. 4—8. PHOTOGRAPHS SHOWING THE POP VALVES FOR INTRODUCING THE SALT SOLUTION, THE ELECTRODES, SOLUTION TANKS AND HEAD AND TAIL WATER LEVEL GAGES ARRANGED FOR THE TEST

measurements of the load were made by M. J. Neall, consulting engineer, while J. H. McCarthy represented Hardy F. Ferguson, consulting engineer for the power company, and J. B. Cutler represented the manufacturers.

Salt Solution Is Injected Through Pop Valves

Water measurements were made in the penstock by the salt velocity method. Salt solution was introduced through four pop valves shown in Fig. 4, placed in a plane near the upper end of the penstock. A 3-in. brine supply line connected the pop valves with the salt tanks, Fig. 5, which were located in the gate house. Brine was mixed in an open tank and fed to the pressure tank as required, the salt solution injection to the penstock being controlled by a quick acting valve in the supply line. A contact switch in the handle of this quick acting valve was wired to the recording ammeter on the test table at the power house, and recorded the introduction of the salt charge on the recording chart.

Two pairs of steel electrodes extended across the lower end of the penstock, as shown in Fig. 6, at the lower end of the penstock. These electrodes were wired to the recording ammeter and recorded the passage of salt solution through the lower end of the test section. The timing for the test was done by a calibrated pendulum clock beating seconds. Elevation of the pond water was measured above the racks by a staff gate on the west side of the forebay while the pressure head at the entrance of the scroll case was measured by a water column connected to piezometer plugs in the penstock walls at that point. This water column was carried outside the power house to an old concrete tower, Fig. 7, where a gage recorded the water elevation. This gage was checked by a wye level. It was also checked with the forebay under static conditions when the unit was shut down.

Elevation of the tail water was measured by two float gages located in stilling boxes in the stop log slots of the pier in the center of the draft tube. These gages, Fig. 8, were checked by a wye level and by a permanent float gage installed inside the power house. Gate openings for each run were set by the station operator and five minutes was allowed for adjustment of load and hydraulic conditions before starting the test run.

Center of Gravity of Salt Charge Used in Calculations

In computing the discharge values, average readings during a run were used. The time of passage of the salt solution is computed from the center of gravity of the introduction of the salt charge to the center of gravity of each final curve. The vertical axis of the center of gravity of each final curve is accurately determined and the time of salt introduction always made half way between the opening and closing of the quick acting valve to give the center of gravity of the salt charge introduction.

Prior to the test the length of the section was accurately measured and cross sections taken at many different stations used for computing the volume. All discharge values were computed by dividing the volume of the test section of the penstock in cu. ft. by the time of the passage of the salt solution in seconds, as computed from the ammeter curves. This gives the discharge in cu. ft. per sec.

For computing the net head, the elevation of the water column connected to piezometers at the entrance of the scroll case was added to the velocity head at that point. From this sum the elevation of the tail water and the velocity head at the exit of the draft tube were subtracted. In computing the overall efficiency, the output of the generator was compared with the theoretical water horsepower as computed from the discharge and the gross head. In computing wheel efficiency, the output of the water wheel was compared with the theoretical water power as computed from the discharge and the net head. The temperature of the water was 70 deg. F. and the weight of water was taken as 62.4 lb. per cu. ft.

For overall efficiencies, the value computed from the test results was transferred to a common gross head of 98.40 ft. in the usual manner. After reduction to a common gross head, curves were drawn through the test points and no derived curves were made. Final efficiencies were plotted against both gate openings and

generator output. For the wheel efficiencies, the values computed for the test results were transferred to a common net head of 97 ft. in the usual manner. In transferring to a common head, no correction was made for change in speed. The total range of head during the test was only 8 in. or 2/3 of 1 per cent of the total head.

Wheel Efficiency Found to Be 92.8 Per Cent for 97 Ft. Head

After reduction to a common net head of 97 ft., curves of b.hp. and discharge plotted against gate openings were prepared from test data. From these two curves, the values for b.hp. and discharge were used for computing wheel efficiencies. The final efficiencies were plotted against both gate opening and b.hp., using the actual gate opening for wheel efficiency and the gate opening indicated by the governor scale for overall efficiency. The wheel efficiency and discharge plotted against b.hp. are shown on Fig. 9 with the actual gate openings indicated.

At 98.40 ft. gross head the maximum overall efficiency is 89.6 per cent. This value occurred at 69 per cent of the gate opening on the governor scale and at 7090-kw. generator output. The maximum efficiency of the wheel at 97 ft. net head and 200 r.p.m. was 92.8 per cent when delivering 9500 b.hp. at 67.5 per cent of the actual gate opening. This is 85.6 per cent of the maximum power developed at full gate, which under conditions of 97 ft. head and 200 r.p.m. was 11,155 hp. with an efficiency of 84 per cent.

The gages installed for head measurements as well as the methods used for reading the gages were exceptionally good. Test sections of the units were sufficiently long to give a positive and clean cut salt velocity curve and all conditions were in favor of accurate results for water measurements. The electrical engineer stated in his report that he believed the determinations of the generator efficiency were within 0.2 of 1 per cent and considering all factors it is a conservative statement to say that the final results of the test are well within 1 per cent of the true value.

While the efficiency test on the wheel was being made, the reducing section of the penstock at the entrance of the scroll case, shown in Figs. 2 and 3, was calibrated for use as a Venturi meter. Piezometer holes at each end of this reducer were connected to a U tube, bromoform diluted with benzine was used in the tube and the deflections and specific gravities were noted. Deflections of the U tube were reduced to an equivalent head, H, in ft. of water and the square root of this value was plotted against the discharge as measured by the salt velocity method. The complete calibration curve is shown in Fig. 10. This calibration can be used in designing recording apparatus to be connected to the same piezometer holes and will provide a reliable and permanent meter for measuring the discharge of the unit.

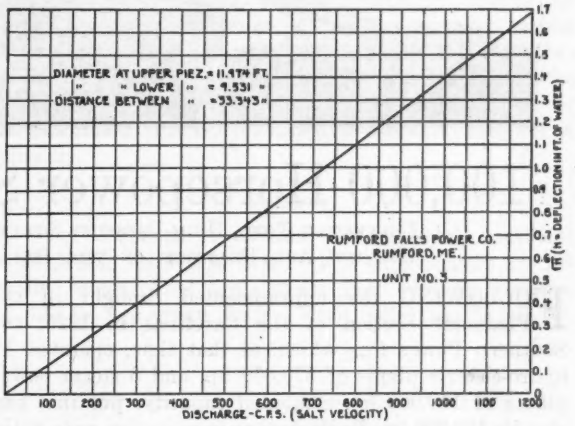

DIAMETER AT UPPER PIEZ. = 11.974 FT.
" " LOWER " = 9.531 "
DISTANCE BETWEEN " = 33.343 "
RUMFORD FALLS POWER CO.
RUMFORD, ME.
UNIT NO. 3
DISCHARGE - C.F.S. (SALT VELOCITY)
H (= DEFLECTION IN FT. OF WATER)

FIG. 10. DAILY WATER MEASUREMENT OF EACH UNIT WILL BE MADE BY MEANS OF THE CALIBRATION CURVE SHOWN ABOVE

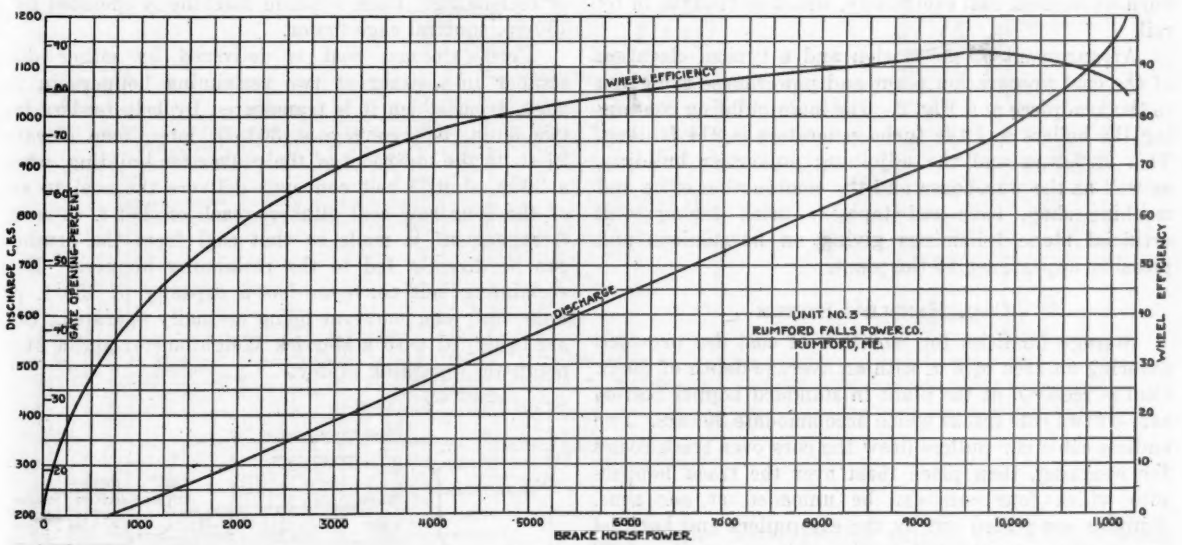
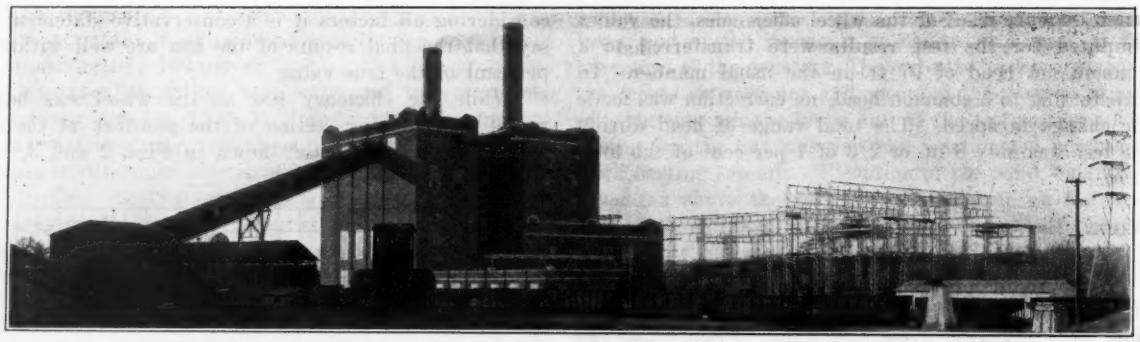


FIG. 9. EFFICIENCY CURVES OF NO. 3 UNIT SHOW A MAXIMUM EFFICIENCY OF 92.8 PER CENT



100,000-Horsepower Steam Auxiliary Station

PULVERIZED FUEL, HIGH-PRESSURE STEAM, SUPERHEAT, AIR PREHEATING AND STAGE HEATING ARE FEATURES OF THE BUCK STEAM STATION. BY RICHARD PFAEHLER*

FOLLOWING the unprecedented drought in the Piedmont Section of the Carolinas in 1925, the Southern Power Co., which, at that time, operated 12 hydro-electric plants of 570,000 hp. and 5 steam power plants of 140,000 hp. combined capacity, put into service its 100,000-hp. Buck steam power station near Salisbury, N. C., in the fall of 1926. In order to have an unfailing supply of condensing water, the plant was located on the Yadkin River, which has a drainage area of 3400 sq. mi. at that point. The plant is designed to burn pulverized coal exclusively, which is brought in by rail.

Arrangement of the station and a typical elevation of the coal preparation plant and powerhouse are given in the headpiece and Fig. 2. The main building containing the boilers and the turbo-generators is 214 ft. long. This structure and the adjoining pulverizer building, as well as the warehouse and the combination office and machine shop, have red tapestry brick facing with artificial stone trimmings giving an harmonious and pleasing appearance to the plant.

COAL HANDLING SYSTEM

Storage facilities for 80,000 t. of coal are provided covering an area of 6 a. with an average depth of 15 ft. Coal is received at the plant in standard hopper bottom cars on two side tracks which accommodate 30 cars. Two endless cable car pullers draw the cars over track scales for weighing, then place them over the track hoppers into which four cars can be unloaded at one time. Empties are pulled out by the car pullers and handled by gravity onto the tail tracks with a capacity of 30 cars, a run-around track enabling the switch locomotive to haul away the empties after the loaded cars are delivered.

From the track hoppers coal is removed by two 30-in. apron conveyors of 300 t. capacity per hr. and, after passing over shaking screens to remove slack, is delivered to two American Ring Roll crushers which break the coal to ½-in. size. From the crushers the coal is handled by two inclined 30-in. belt conveyors, 104 ft. long, which deliver it by means of movable spouts to the initial storage pile, whence it is distributed into the storage yard by two 4-t. Beaumont drag scrapers of 150 t. capacity an hour at a 250 ft. radius for either storing or reclaiming. Each winding machine is operated by a 150-hp. squirrel cage motor.

From storage, coal is delivered by either drag scraper into either of two reclaiming hoppers in the yard, from which it is transferred by belt feeders into two 30-in. belt conveyors, 303 ft. long, then elevated 94 ft. to the top room of the pulverizer building, where a 30-in. shuttle belt conveyor delivers the coal to any of the four raw coal bunkers, each of 250 t. capacity. Arrangement is made so that coal from the crushers can be directly fed to the reclaiming hoppers. Each reclaiming belt conveyor has a capacity of 150 t. per hour, only one conveyor being normally operated. Both are equipped with a Merrick Weightometer and a 24-in. magnetic separator pulley.

*Designing engineer with Wm. S. Lee, consulting engineer.

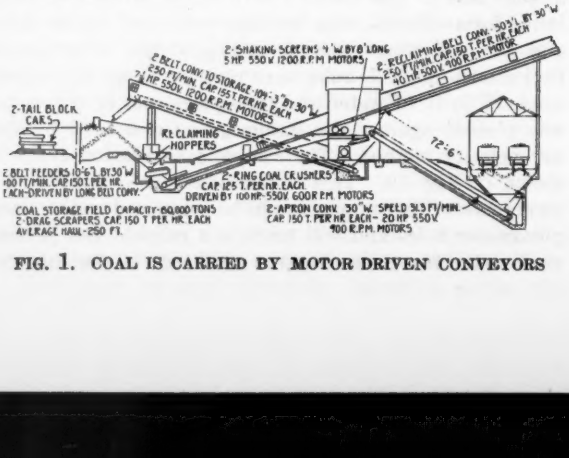

2-SHAKING SCREENS 4'W BY 8'LONG
5 HP 550 V 1200 R.P.M MOTORS
2-RECLAIMING BELT CONV. 303'L BY 30"W
2-BELT CONV. 10 STORAGE 104'L BY 30"W
2-TAIL BLOCK CARS
RECLAIMING HOPPERS
2-BELT FEEDERS 10'6"L BY 30"W
2-RING GRAN. CRUSHERS
2-APRON CONV. 30"W. SPEED 363 FT/MIN
COAL STORAGE FIELD CAPACITY-80,000 TONS
2-DRAG SCRAPERS CAP 150 T. PER HR. EACH
AVERAGE HAUL-250 FT.

FIG. 1. COAL IS CARRIED BY MOTOR DRIVEN CONVEYORS

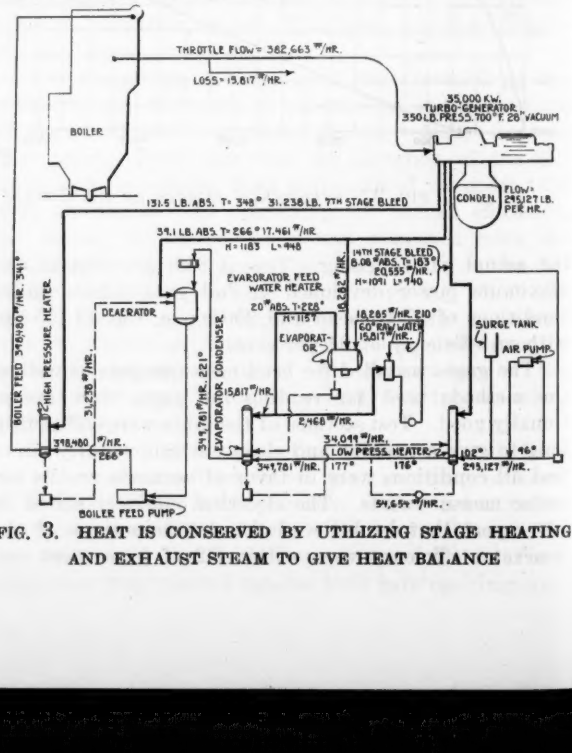

THROTTLE FLOW = 382,663 #/HR.
LOSS = 15,817 #/HR.
35,000 K.W. TURBO-GENERATOR 350 LB. PRESS. 700° F. 28" VACUUM
BOILER
131.5 LB. ABS. T = 348° 31,238 LB. 7TH STAGE BLEED
CONDEN.
FLOW = 245,127 LB. PER HR.
39.1 LB. ABS. T = 266° 17,461 #/HR.
14TH STAGE BLEED
EVAPORATOR FEED WATER HEATER
DEAERATOR
EVAPORATOR
60° RAW WATER 15,817 #/HR.
SURGE TANK
AIR PUMP
BOILER FEED 382,480 #/HR. 341°
HIGH PRESSURE HEATER
EVAPORATOR CONDENSER
BOILER FEED PUMP

FIG. 3. HEAT IS CONSERVED BY UTILIZING STAGE HEATING AND EXHAUST STEAM TO GIVE HEAT BALANCE

Raw coal bunkers are of the steel suspension type, unlined. From each bunker the coal flows by gravity through a live-steam heated dryer to remove moisture, then discharges into the pulverizing mill. Each of the four pulverizing mills has a rated capacity of 15 t. an hour, three of these mills being sufficient to serve the boilers when the plant is operated at full load. Raw coal supply to each mill can be regulated by an automatic feeder located at the coal inlet of the mill. The powdered coal is blown from the mill by a motor-driven exhauster into the mill collector on the roof of the pulverizing building, whence it flows through a diverting valve into either one of duplicate screw conveyors. These screw conveyors run the entire length of the floor and are arranged to receive powdered coal from any of the four mill collectors, discharging it into a cross conveyor leading to the boiler house. Then by means of distributing conveyors the material is delivered to the pulverized coal bunkers, each of 80 t. capacity, located above and in front of each firing side of the boilers. Screw conveyors carrying coal from the mill collectors to the pulverized coal bunkers are in duplicate, either one having sufficient capacity to carry the output of three mills. The cross conveyor to the boiler room is 60 ft. long and is inclined upward towards its discharge end at an angle of 5½ deg. It will be noted that each mill has its own individual coal bunker, coal dryer, mill exhauster, dryer exhauster, mill collector, and dryer collector, with one air washer for each two dryer collectors. Each dryer exhauster forces the steam from the coal dryer through the dryer collector and air washer to the atmosphere. The pulverizer building is steam heated by two American Blower Co.'s Venturafin heating units located on the ground floor.

From each of the pulverized coal bunkers, which are of plate steel construction lined with Weber's cement, fuel flows by gravity to 14 individual motor-driven feeders for each boiler, where it mixes with the air supplied from a common header running in front of the four boilers. Four feeder blowers are installed on the feeder floor, furnishing the air to the header so that air supply to all feeders is insured in case some of the fans are not in operation. The mixture of fuel and air is blown vertically into the furnace through fantail type burners.

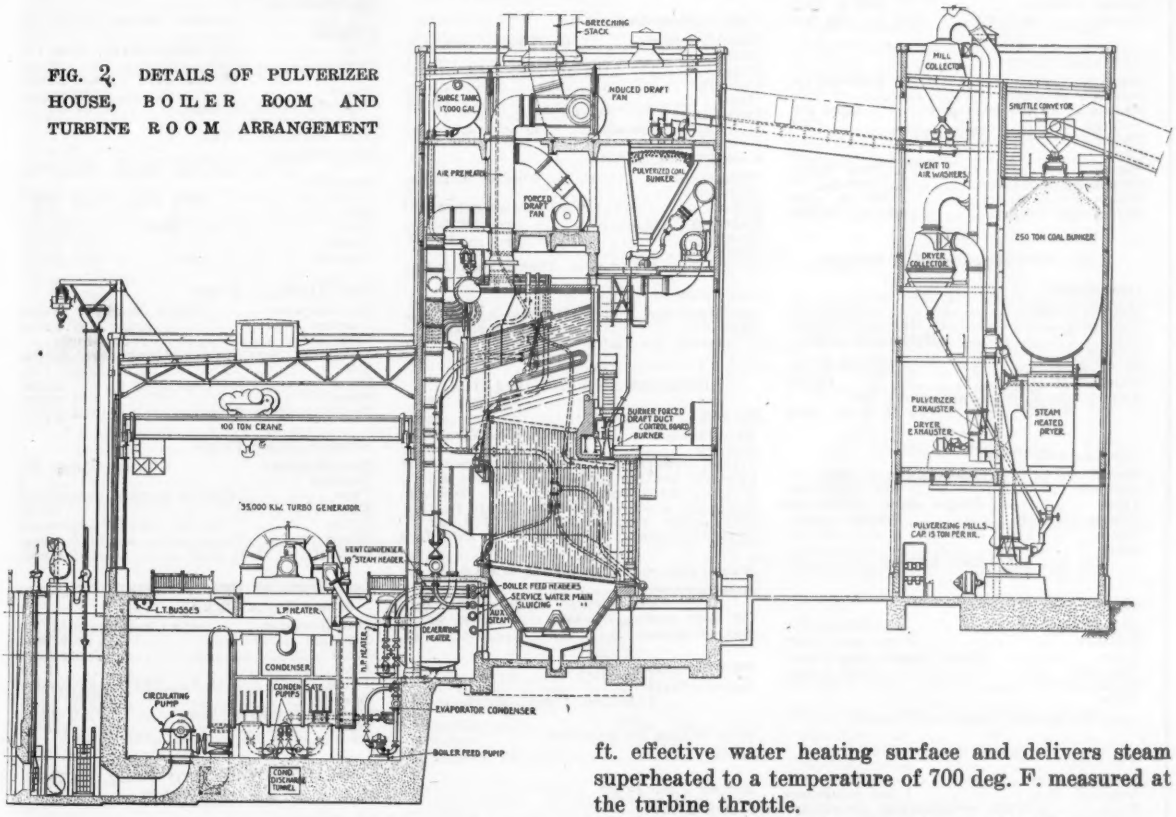


FIG. 2. DETAILS OF PULVERIZER HOUSE, BOILER ROOM AND TURBINE ROOM ARRANGEMENT

Boilers

Four Babcock & Wilcox wrought-steel, sectional cross-drum, water-tube boilers with superheaters are installed, constructed for a steam gage working pressure of 425 lb. per square inch. Each boiler has 26,601 sq. ft. effective water heating surface and delivers steam superheated to a temperature of 700 deg. F. measured at the turbine throttle.

Each boiler is equipped with fin-tube side and rear walls, air cooled arch at the front and water tube screen above the ash pit. Above the smoke outlet of the boiler, an air heater of the Combustion Engineering Co.'s type is arranged in a vertical position. Furnace draft conditions are maintained by an induced draft fan, which takes its suction from the top of the air preheater and discharges into the horizontal smoke breeching, on top of the roof, extending to a steel stack 13 ft. diameter and serving two boilers.

Forced draft fans located on the heater floor take the air at room temperature and discharge it downward through the air preheaters. The outlet from each air preheater is divided into two ducts which run down in

the rear of the boiler to below the operating floor, then turn along the side of the furnace and, at the connection with the furnace near the front, are provided with registers. One bleeder duct branches from one forced draft duct and runs to a header forming the inlet to two feeder blowers; the other bleeder duct runs across the front of the furnace above the arch and supplies air to the burners.

way, which runs under the ash pits and discharges into a water-proofed concrete sump outside the boiler house. Particles which are sluiced through the 3½-in. mesh steel screen, 15 ft. long by 13 ft. 6 in. wide, arranged horizontally in the sump, are pumped into the river a short distance below the plant, whereas the clinkers deposited on top of the screen are removed by a ¾-yard grab bucket and loaded into coal cars for disposal.

Principal Equipment at Buck Steam Station

TURBO-GENERATORS

Main Unit

Manufacturer .....General Electric Co.
Number of units 2
Rating at 80 per cent p. f.....35,000 kw.
Voltage 13,200
Phase 3
Cycles 60
Speed .....1800 r.p.m.
Steam temperature .....700 deg. F.
Steam pressure .....350 lb. gage
Direct con. exciter.....250 v., 200 kw.

Auxiliary Unit

Manufacturer .....General Electric Co.
Number of units 1
Rating at 80 per cent p. f.....3000 kw.
Voltage 2300
Phase 3
Cycle 60
Speed .....3600 r.p.m.
Steam temperature .....700 deg. F.
Steam pressure .....350 lb. gage
Direct con. exciter .....250 v., 29 kw.

MAIN CONDENSING EQUIPMENT

Condenser

Manufacturer .....Elliott Co.
Number .....One per turbine
Type .....Horizontal surface
Passes 2
Exposed surface .....54,000 sq. ft.
Number of tubes 10,344
Tubes, 1 in o. d. muntz metal, No. 18 B. W. G.....20 ft. 0 in. long

Circulating Pump

Manufacturer .....Allis-Chalmers Mfg. Co.
Number .....2 per condenser
Type .....Single stage centrifugal
Capacity, each.....32,500 g.p.m.
Head .....21 ft.
Drive .....
250 hp., 285 r.p.m., 2200 v., a.c. motor

Condensate Pump

Manufacturer .....Elliott Co.
Number .....2 per condenser
Type .....Single stage centrifugal
Capacity .....1000 g.p.m.
Head .....152 ft.
Drive .....
100 hp., 1740 r.p.m., 2200 v., a.c. motor

Air Pump

Manufacturer .....Elliott Co.
Number .....1 per condenser
Type.....Twin combination air ejector
Capacity, 2 in. abs.....
.....190 lb. r 380 lb. per hr.

AUXILIARY CONDENSING EQUIPMENT

Condenser

Manufacturer .....C. H. Wheeler Mfg. Co.
Number 1
Type.....Dual bank, horizontal surface
Passes 2
Surface .....5000 sq. ft.
Number of tubes 1194
Tubes, 1 in o. d. muntz metal, No. 18 B. W. G. .....16 ft. 2 in. long

Circulating Pump

Manufacturer .....C. H. Wheeler Mfg. Co.
Number 1
Type .....Single stage centrifugal
Capacity .....6000 g.p.m.
Head .....20 ft.
Drive .....
40 hp., 690 r.p.m., 2200 v., a.c. motor

Condensate Pump

Manufacturer .....C. H. Wheeler Mfg. Co.
Number 1
Type .....Two stage centrifugal
Capacity .....90 g.p.m.
Head .....192 ft.
Drive .....
15 hp., 1740 r.p.m., 2200 v., a.c. motor

Air Pump

Manufacturer .....C. H. Wheeler Mfg. Co.
Type .....Duplex, 2 stage, steam jet, inter and after condenser

BOILERS AND AUXILIARIES

Boiler

Manufacturer .....Babcock & Wilcox Co.
Number 4
Type.....Sectional cross drum water tube
Effective heating surface.....26,601 sq. ft.
Nominal rated capacity.....2660 hp.
Maximum working pressure....425 lb. gage
Total steam temp. at throttle...700 deg. F.
Type superheater.....B. & W. Interdeck

Water Screens and Water Walls

Manufacturer .....
.....Combustion Engineering Corp.
Eff. heat. surf. per boiler.....2585 sq. ft.
Size of tubes .....4 in.

Soot Blowers

Manufacturer .....
.....Diamond Power Specialty Co.

Feed Water Regulators

Manufacturer.....The Swartwout Co.

Boiler Feed Pump

Manufacturer .....
.....A. S. Cameron Steam Pump Co.
Number 4
Type .....Six stage, class HMT
Size .....5 in.
Drive.....3 by motor and 1 by turbine
Horsepower .....
....450 hp. motor and 413 hp. turbine
Speed .....1750 r.p.m.
Capacity at 475 lb. gage.....1070 g.p.m.

MISCELLANEOUS PUMPS

House Service Pump

Manufacturer .....
.....A. S. Cameron Steam Pump Co.
Number 3
Type.....Single stage, class LV
Size .....6 in.
Drive.....60 hp., 2200 v., a.c. motor
Speed .....1750 r.p.m.
Capacity at 52 lb. gage.....1500 g.p.m.

Ash Sluicing Pump

Manufacturer .....
.....A. S. Cameron Steam Pump Co.
Number 2
Type .....Two stage, class HMT
Size .....6 in.
Drive.....150 hp., 2200 v., a.c. motor
Speed .....1750 r.p.m.
Capacity at 135 lb. gage.....1250 g.p.m.

Ash Handling Pump

Manufacturer.....Morris Machine Works
Number 2
Type .....Single stage heavy duty Manganese dredge
Size .....6 in.
Drive .....60 hp., 2200 v., a.c. motor
Speed .....695 r.p.m.
Capacity at 30 lb. gage.....1350 g.p.m.

Station Sump Pump

Manufacturer .....Chicago Pump Co.
Number 2
Type .....Duplex vertical centrifugal
Size .....4 in.
Drive .....7½ hp., 550 v., a.c. motor
Speed .....1720 r.p.m.
Capacity at 22 lb. gage .....250 g.p.m.

Low Pressure Heater Drainer Pump and Surge Tank Pump

Manufacturer .....Allis-Chalmers Mfg. Co.
Number .....2 each
Type .....Centrifugal
Size .....2 in.
Drive .....15 hp., 550 v., a.c. motor
Speed .....3500 r.p.m.
Capacity at 65 lb. gage .....150 g.p.m.
Head .....150 ft.

EVAPORATORS AND FEED WATER HEATERS

Evaporator

Manufacturer....The Griscom-Russell Co.

Boilers are arranged in one row lengthwise of the building, the inside of the boiler room being 210 ft. long, 56 ft. wide and 110 ft. high measured from the basement floor. Besides the stairway an automatic push-button passenger elevator is available; also all floors above the basement are provided with trap doors which, when open, form a shaft through which materials may be lifted to any floor by means of a 5-t. hoist suspended under the roof.

Ashes are handled by means of a hydraulic sluice-

Outside dimensions of each boiler and combustion chamber, are as follows:

	Boiler	Furnace
Length	26 ft. 2 in.	28 ft. 1¼ in.
Width	34 ft. 2 in.	34 ft. 2 in.
Height	28 ft. 4½ in.	29 ft. 7⅝ in.

All boilers are provided with steam-operated soot blowers. Automatic control of feed water level is maintained by S-C feed-water regulators while combustion

regulation is effected by hand from a control board for each boiler.

Feed Water System

Evaporator feed-water heaters and evaporators are located on the heater gallery of the boiler room, the make-up water for each turbine being passed into the evaporator feed-water heater by means of a float valve. It is discharged by the evaporator feed pump to the pressure heater near its entrance and leads to its surge tank arranged on the top floor of the boiler room to take care of surges during periods of unbalanced steam conditions between the boiler and turbine. Provision is made so that the two surge tanks can be used together as one unit. Overflow piping is so arranged that, in case one of the tanks fills up, the overflow will pass into the other surge tank until the latter is filled; there-

Principal Equipment at Buck Steam Station—Concluded

Number 2
Type ..... Film, bentube, self scaling

Evaporator Feed Heater
Manufacturer ..... Griscom-Russell Co.
Number 2
Type ..... Open

Evaporator Condensers, Low Pressure Heaters, High Pressure Heaters
Manufacturer ..... Griscom-Russell Co.
Number ..... 2 each
Type ..... Condenser

COAL HANDLING EQUIPMENT

Drag Scraper
Manufacturer ..... R. H. Beaumont Co.
Number 2
Bucket capacity ..... 4 t.
Capacity 250 ft. radius .... 150 t. per hr.

Tail Block Car and Winding Drum
Manufacturer ..... R. H. Beaumont Co.
Number 2

Track Scale
Manufacturer ..... Fairbanks Co.
Number 2

Coal Crusher
Manufacturer .... American Pulverizing Co.
Number 2

Apron Conveyors, Belt Conveyors, Shuttle Conveyor, Structural Steel Bridges; Crusher House, Unloading Hopper and Unloading Shelter
Manufacturer ..... Link-Belt Co.

Structural Steel in Buildings and Coal Hoppers
Manufacturer ... Virginia Bridge & Iron Co.

DRYING, PULVERIZING AND COMBUSTION EQUIPMENT

Dryers, Lopulco, Steam Heat
Manufacturer ..... Combustion Eng. Corp.

Dryer Exhauster
Manufacturer ..... American Blower Co.
Drive .....
50 hp., 1200 r.p.m., 2200 v., a.c. motor
Number 4

Pulverizer
Manufacturer ..... Combustion Eng. Corp.
Number 4
Type ..... Raymond 6 roll
Capacity ..... 15 t. per hr.
Drive .....
200 hp., 450 r.p.m., 2200 v., a.c. motor

Mill Exhauster
Manufacturer ..... Combustion Eng. Corp.
Type ..... Raymond
Number 4
Drive .....
100 hp., 1200 r.p.m., 2200 v., a.c. motor

Mill Automatic Feeder
Manufacturer ..... Combustion Eng. Corp.
Type ..... Raymond
Number 4
Drive .....
1 hp., 900 r.p.m., 550 v., a.c. motor

Pulverized Coal Collectors
Manufacturer ..... Combustion Eng. Corp.
One 9 ft. 0 in. dia. mill collector and
One 9 ft. 4 in. dia. drier collector for each mill.

Pulverized Coal Conveyor
Manufacturer ..... Combustion Eng. Corp.
Number ..... 2 sets
Type ..... Screw
Capacity ..... 55 t. per hr.

Pulverized Coal Feeder
Manufacturer ..... Combustion Eng. Corp.
Number per boiler 14
Total number 56
Drive ..... 1½ hp. var. speed d.c. motor

Burners
Manufacturer ..... Combustion Eng. Corp.

SMOKE STACKS AND FLUES

Stack
Manufacturer ..... R. D. Cole Mfg. Co.
Number 2
Type ..... Steel, unlined
Diameter ..... 13 ft. 0 in.
Height above roof ..... 76 ft. 9 in.
Support ..... Building steel

Breeching and Flues
Manufacturer ..... R. D. Cole Mfg. Co.

CRANES AND HOISTS

Turbine Room Crane
Manufacturer ..... Niles Crane Corp.
Number 1
Capacity ..... 100 t.

Boiler Room Crane
Manufacturer ... Shepard Elec. C. & H. Co.
Number 1
Capacity ..... 5 t.

Ash Handling Trolley
Manufacturer ..... Euclid C. & H. Co.
Number 1
Capacity ..... ¾ yard clamshell

Cranes in Pulverizer Building
Manufacturer ..... Euclid C. & H. Co.

Location	Cap.	Drive	No.
Over mills	5 t.	Hand	2
Over shaft	2 t.	Motor	1
Over coal bunkers	2 t.	Hand	1

Hoist Above Water Supply Intake
Manufacturer ..... Euclid C. & H. Co.
Number 1
Capacity ..... 25,000 lb.
Drive ..... Motor

PIPING AND VALVES

Piping Contractor
..... Grinnell Co.

Pipe Covering Contractor
..... Guy M. Beaty

Valves

	Manufacturer
H. p. globes	The Edward Valve & Mfg. Co.
H. p. gates	Chapman Valve & Mfg. Co.
H. p. checks	Chapman Valve & Mfg. Co.
Atmos. Relief	The Edward Valve & Mfg. Co.
11th stage bleeder relief	Crane Co.
Evap. relief	Kieley & Mueller, Inc.
Std. and l. p. gate and checks	Chapman Valve & Mfg. Co.

MISCELLANEOUS

Ash Hoppers, Ash Gates and Ash Sluiceway
Manufacturer ..... Allen-Sherman-Hoff Co.

Generator Air Coolers
Manufacturer .... The Griscom-Russell Co.

Tanks
Manufacturer ..... R. D. Cole Mfg. Co.

Exhaust Heads
Manufacturer ..... Swartwout Co.

H. P. Steam Drainage Control System
Manufacturer ..... The Swartwout Co.
Pressure Reducing Valves
Manufacturers ..... Fisher Governor Co., Mason Regulator Co.

Car Pullers
Manufacturers ..... Link-Belt Co.

evaporator, which is supplied with steam from the eleventh stage nozzle of the turbine. The evaporator feed-water heater is provided by a bypass so that raw water can be injected directly into the evaporator. Vapor generated is condensed in a surface condenser, the drains from the evaporator coils and the condensed vapor being passed to the low-pressure heater, which receives its steam from the fourteenth stage of the turbine, thence to the deaerator for degassing.

Riser to the surge tank is connected to the low-pressure heater near its entrance and leads to its surge tank arranged on the top floor of the boiler room to take care of surges during periods of unbalanced steam conditions between the boiler and turbine. Provision is made so that the two surge tanks can be used together as one unit. Overflow piping is so arranged that, in case one of the tanks fills up, the overflow will pass into the other surge tank until the latter is filled; thereupon the overflow passes into a large distilled-water storage tank located in the basement of the turbine room. Pumps are installed under this storage tank so that the water can be pumped from it into the surge tanks to make up any deficiency. These storage tanks also receive the various drips and drains.

From the deaerator the feed water is passed to the high-pressure heater by means of the boiler feed pumps, thence to the boilers at a temperature of 341 deg. F. The high-pressure heater uses steam bled from the

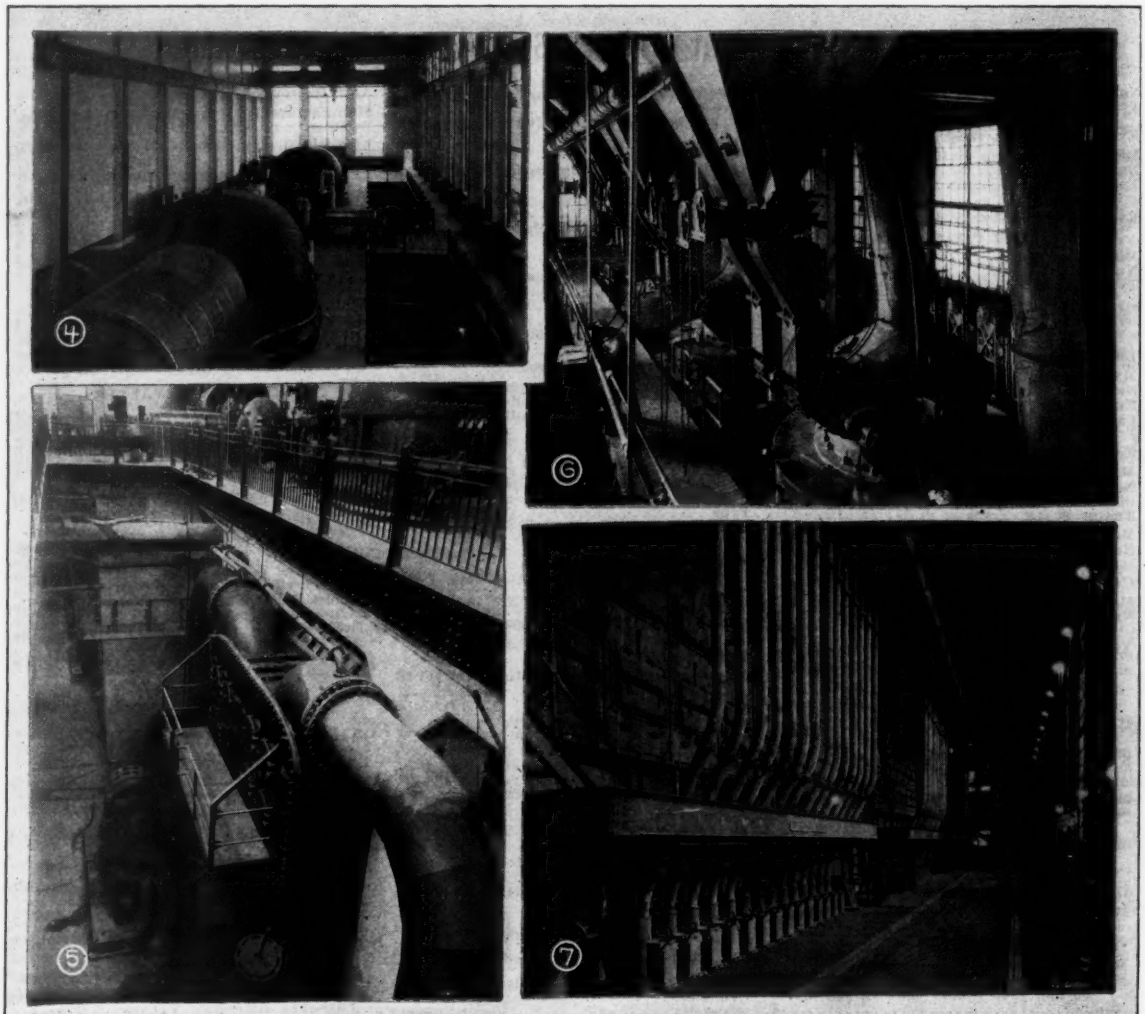
seventh stage of the turbine and the drain therefrom is passed to the deaerator.

Steam Supply

From the boilers steam passes to the main steam header located at floor level in the rear of the boilers. This header has a sectionalizing valve and, under normal operating conditions, either half of the plant is run as a unit independently of the other. Two lines bent below the floor carry the high pressure steam to the turbines.

An auxiliary header, taking steam from and running below the main header, serves both the steam line to the auxiliary turbo-generator, arranged between the two main units, and the steam line to the air ejectors on the main condensers. Connection to a steam-turbine-driven boiler feed pump, serving as a stand-by unit, is also provided. Otherwise all station auxiliaries are motor operated.

Separated by a brick wall from the boiler room, the turbine room is 210 ft. long by 57 ft. 1¼ in. wide. The operating floor and the inside face of the concrete water table are covered with glazed red tile while the wall faces are plastered and painted a light color. Large window sashes are built of steel, the roof consisting of reinforced gypsum slabs resting on steel purlins, the tops of the slabs having a finish of tar and gravel. The structural steel frame of the turbine building is mostly encased by the brick and supports the steel runways for the 100-t. capacity electric crane in the turbine room.



FIGS. 4-7. TYPICAL VIEWS OF THE MAJOR EQUIPMENT SHOW THE ARRANGEMENT OF THE TURBINE ROOM, CONDENSER PIT, PULVERIZER HOUSE AND BOILER ROOM

All auxiliary equipment is located in the basement which obtains natural light through two large wells in the operating floor.

Two main turbo-generators are installed with their shafts lengthwise of the turbine room, the auxiliary turbo-generator being located crosswise between the two main units. All turbines are of the Curtis type manufactured by the General Electric Co. and take steam at the throttle at 350 lb. and 700 deg. F. Each main generating unit is rated 35,000 continuous kw. at 80 per cent power factor, 1800 r.p.m., 13,200 v., 3-phase, 60 cycles; has 17 stages and bleeder openings are provided

at the seventh, eleventh and fourteenth stages; it has a direct connected exciter of 200 kw. and 250 volts. Each unit has its individual oil lubrication system with the oil pump geared to the main shaft and an auxiliary oil pump mounted on the turbine oil tank.

The auxiliary 3600-r.p.m. turbo-generator has a rating of 3000 continuous kw. at 2300 v., 3-phase, 60 cycles.

Foundations for the turbo-generators consist of structural steel, the design calling for a maximum deflection of girders and maximum shortening of columns of 0.02 in., considering 25 per cent vertical impact and 25 per cent horizontal thrust, besides the dead weight of the machines and of the foundation. Under these conditions the maximum calculated stresses are less than

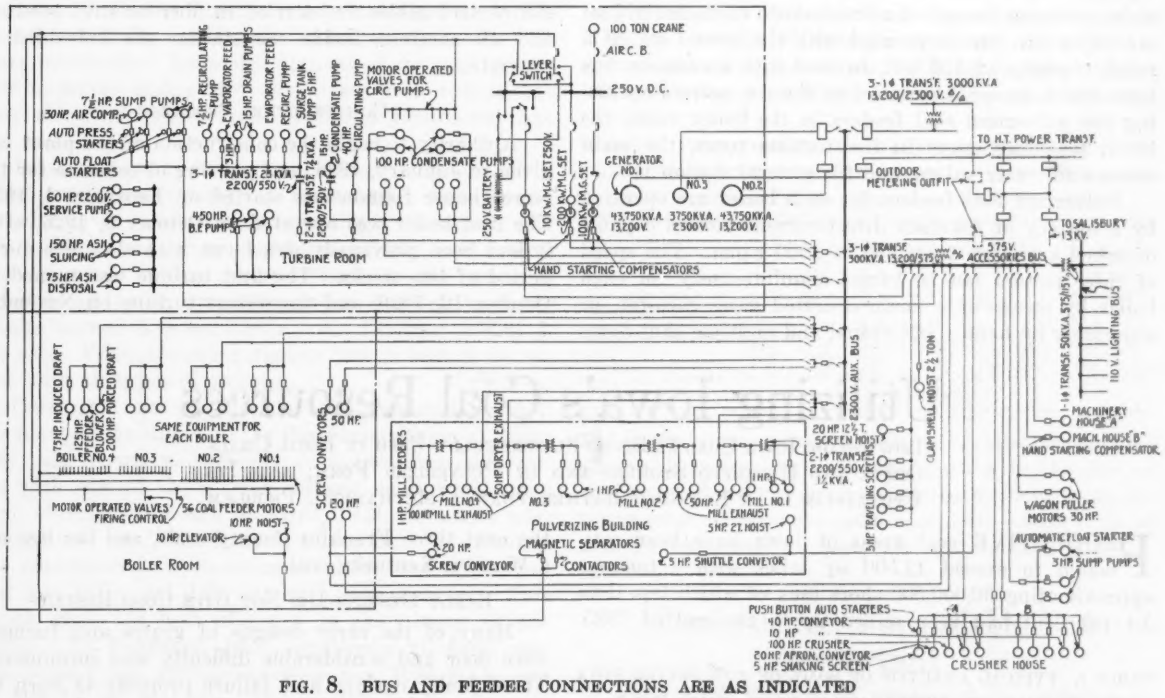


FIG. 8. BUS AND FEEDER CONNECTIONS ARE AS INDICATED

4000 lb. per sq. in. The structural steel is heavily encased in concrete and the structure supporting the unit is detached from the rest of the building so that no vibration can be transmitted from one machine to another to disturb the smooth operation of the rotating element.

Each main generator is equipped with a closed ventilating system and a fin-type surface air cooler for cooling the recirculated air. From the auxiliary generator the hot air is discharged through a duct to the outside of the building.

Turbines exhaust into surface condensers of 54,000 sq. ft. each, for the main units and of 5000 sq. ft. for the auxiliary turbine. These are rigidly connected to the turbine casings and spring supported. Duplicate motor driven condensate pumps and circulating pumps are provided with each condenser.

At full load operation each main surface condenser requires 65,000 g.p.m. of cooling water and the auxiliary condenser 5000 g.p.m., or a total of 135,000 g.p.m. In addition, the necessary water for the ash sluicing pumps and for the service pumps furnishing water to the generator air coolers, turbine oil coolers, transformers, make-up water and other station use must be provided.

Water is received from the river through a concrete intake forming an extension of the power house substructure. It first passes through a set of stationary racks to collect the large debris, then through five Link-Belt Co. traveling screens. Five short tunnels under the basement floor connect with the suctions to the circulating pumps, so arranged that two pumps serve the main condensers and the fifth pump, located centrally between the main condenser pumps, delivers the water to the auxiliary condenser. A branch connection from the center tunnel supplies water to the three service pumps and the two ash sluicing pumps. Circulating water from the condensers is returned to the river by two discharge tunnels, 6 ft. wide by 5 ft. high.

Electrical Features

Located on the mezzanine floor at the downstream end of the turbine room is the main control switchboard.

Outgoing 13,200-v. lines lead to the outdoor transformer and switching station adjoining the power house. Three water-cooled, single phase, 14,500-kv.a. transformers, 13,200-v. delta to 101,200-v. star, are served by each main generating unit. For the operation of the station auxiliaries, one 9000-kv.a., 13,200 to 2300-v. transformer bank and one 900-kv.a., 13,200 to 575-v. transformer bank are provided in the outdoor station. The 13,200-v. bus section, to which the auxiliary transformers are connected, is interlocked by means of oil circuit breakers so that, in case of failure of voltage on one generator bus, it is automatically released from this bus and transferred to the other one provided that power is available on that bus.

The circuit from the 3000-kw., 2300-v. auxiliary generator in the power station is connected to the 2300-v.

bus supplied by the 9000-kv.a. outdoor transformer bank. All station auxiliaries are connected to this bus, except the motors for the coal preparation equipment outside the pulverizer building and other incidental auxiliaries which are operated at 575 v. from the 900-kv.a. transformer bank during shut-downs of the plant. Most of the motors are of the "across-the-line" squirrel-cage induction type but, for conveyor and fan service, wound rotor induction motors are installed. To decrease the fire hazard, standard outdoor-type oil circuit breakers are installed for motor control wherever possible.

Two 250-v. direct-current motor-generator sets are installed in the turbine room. One set of 200 kw. rated capacity can be used to supply excitation current to a main generator in case of a break-down of its individual exciter or can run in parallel with the second set, of a rated capacity of 100 kw., to feed into a common bus from which power is supplied to the d.c. motors operating the pulverized coal feeders in the boiler room, the 100-t. traveling crane in the turbine room, the main steam and water valves, and for general station use.

Pulverized coal feeders for each boiler are operated by a battery of fourteen direct-current motors capable of speed variation from 400 to 2000 r.p.m. The speed of these motors can be varied simultaneously for each boiler by means of a motor-operated gang rheostat, or separately by hand. Individual and multiple shut-down of all or any selected number of motors is provided by push button control at the main boiler switchboard. For emergency supply, a 250-volt storage battery of 320 ampere-hours is provided in the basement of the power station, capable of operating control of the circuit breakers, dead lights on switchboard, a reduced number of motors for pulverized coal feeders and motors for steam and water valves.

Complete control is also provided at the main boiler switchboard for the induced and forced draft fans and for the feeder blowers, which are equipped with 2200-v., a.c. motors. The d.c. motor-operated steam and water valves are equipped with standard and emergency control. Interchangeable truck type steel panels are installed for the control of the motors in the turbine room. All control cables are carried in fiber or steel conduits and all conduits inside the station are imbedded in concrete.

Construction Progress

Authority to begin the construction of the plant was given in January, 1926, and pouring of concrete for the power house foundations started on February 4, 1926. The first boiler was operated on October 8, 1926, after it had been previously dried out with slow fire for a period of two weeks. The first turbine was turned on October 12, 1926, and the second turbine on November 4, 1926.

Utilizing Iowa's Coal Resources

Low Grade Iowa Coal Is Being Successfully Used in Both Chain Grate and Underfed Stokers and in Pulverized Form, and Its Utilization Is an Economic Rather than a Mechanical Problem

PRODUCTIVE coal areas of Iowa have been estimated to exceed 12,500 sq. miles with a tonnage approximating 30,000,000 short tons of which less than 1.4 per cent had been mined up to the end of 1925.

TABLE I. TYPICAL ANALYSIS OF SOME OF THE BETTER IOWA COALS COMPARED WITH SAMPLES FROM OTHER FIELDS

	Dallas Co., Ia.		Des Moines, Ia.			Franklin Co., Ill.			West Ky.	
Moisture	Dry	16.64	10.12	11.09	13.66	13.66	6.53	5.98	6.56	9.30
Volatile	37.7	29.38	31.60	29.65	30.35	27.62	37.47	38.71	37.51	33.20
Fixed Carbon	48.6	31.80	34.58	34.97	38.00	30.44	46.12	46.14	45.03	51.30
Ash	13.7	22.18	23.70	24.97	17.99	28.38	9.88	9.17	10.88	6.20
Sulphur	4.0	4.38	5.39	6.72	4.24	6.20	3.06	3.17	3.31	2.89
B.t.u./lb.	12.51	8.478	8.884	8.167	9.246	7.333	11.962	12.143	11.823	12.995
Cost/ton	3.75	2.97	2.63	2.48	2.74	2.65	6.52	5.74	5.09	6.00

Utilization of these resources from the standpoint of the geologist, the miner, the combustion engineer and the research engineer were covered at the Iowa Power Conference in papers presented by James H. Lees, T. H. Marsh and B. F. Fleming.

Iowa coals are all relatively soft, of high ash and high sulphur content with the percentage of volatile nearly as high as that of the fixed carbon. They do not stand air storage well, as the sulphur oxidizes and the coal breaks down. Comparison of a large number of analyses of Iowa and Illinois coals, however, shows that they do not differ greatly in heat content or chemical composition. Analyses of what may be considered average samples are shown in Table I from analyses of various steam coals, the first seven being Iowa coals, the next three Franklin County coals, and the last one a Western Kentucky coal.

Early Designs Did Not Give Good Results

Many of the early designs of grates and furnaces were poor and considerable difficulty was encountered. These faulty designs and failure properly to burn the coals of Iowa were due largely to the lack of thorough knowledge regarding fuel characteristics, lack of knowledge of combustion and the fact that in many cases that if Iowa coal gave difficulty, Illinois or other coal could be substituted.

Physical and combustion characteristics of the coal have now been established and the coals are well known chemically. In general they may be classified as free-burning bituminous of high ash content with an ash diffusion temperature usually below 2200 deg. F. The high ash content of the coal makes it difficult to ignite and very slow to burn in fuel beds. The low fusion temperature of the ash makes the coal very susceptible to clinker formation at ordinary furnace temperature. This clinker formation retards combustion and further reduces the amount of coal which can be burned.

Earlier installations were largely of the inclined overfed type stoker which gave considerable difficulty from clinker formation and limited capacities of the dumping plates. Combustion rates were low, ash pit losses were high, operation was difficult and maintenance excessive. These installations were followed by early designs of underfed stokers which were not entirely

successful and were followed by natural draft chain grates. From the general analysis of average Iowa coal, it is evident that this type of stoker was more suitable than even the overfed or underfed type, as clinkers were avoided. Test results of one plant are given in Table II.

Forced Draft Stokers Hasten Combustion

About six years ago the forced draft chain grate was successfully applied to bituminous coals. This factor added much to the performance obtainable with Iowa coal. Some of the poorer grades are so inert that under natural draft conditions combustion rates are too low to maintain a high furnace temperature. This in turn reacts on the ability to ignite more coal and the use of forced draft and various zones and compartments in stokers furnishes a means of regulating the air supply to improve ignition and greatly increase the combustion rates obtainable. Later installations of the multiple retort underfed stoker have given improved results, but they are considerably more liberal in grate area than the earlier type.

Iowa coal burns best when reduced to a size all of which will pass through a 1-in. round hole screen. Moistening or tempering is exceedingly important and the better combustion engineers of the state have learned much in this regard. Three to five per cent moisture added at least 2 hr. before burning improves results in regard to combustion rate, CO_2 and carbon in the ash. From operating reports this is said to be the case with all types of stokers.

Pulverized coal installations have been made in various parts of the state and the Big Sioux station at Sioux City, Ia., reports no difficulty in maintaining high rating with any of the several midwest coals which they use. During the month of April, 1926, the major portion of coal used was from Waukee, Ia. No difficulty was encountered in operating at ratings up to 350 per cent and little real difficulty with slag reported. This month gives the best efficiency in the history of the station. In February, 1927, practically all Iowa coal was burned, the average analysis was 9100 B.t.u. per lb. with 18 per cent ash. The monthly boiler efficiency was 84.5 per cent.

High Ash Helps Combustion in Pulverized Fuel Furnaces

High efficiencies with Iowa coal has caused some thought to be given to the reason. The theory has been advanced that the surfaces of the ash section accelerate the effects of combustion. This is in accordance with tests made at the Mines de Blanzy, France, where it was proven that ash volume had a beneficial effect on combustion when pulverized coal is burned by short flame travel. Ample cooling equipment should be installed in pulverized coal furnaces to reduce the temperature of the walls to a point below that of the melting point of the ash. This temperature, for Iowa coals, is low and can be successfully reached by means of water screens. Preheated air for combustion is very desirable and increases the combustion rate and furnace temperature, making more necessary than ever the use of radiant water or steam walls, to reduce furnace maintenance.

In plants where the economies of the problem indicate stokers the most desirable type of stoker is the forced draft traveling grate with preheated air and water walls. For those installations not requiring the higher capacity obtainable with pulverized fuel or with forced draft, the natural draft chain grate stoker is suitable. Such installations should be made with liberal arches, at least 60 per cent of the stoker length and set high above the fuel bed. Stokers for coals should have liberal grate areas and should be preferably 12 ft. or longer.

Both for domestic use and industrial purposes, however, Iowa coal shows certain qualities and properties which mitigate against its more general use. It suffers from an inferiority complex due to the fact that these disagreeable and poor qualities have been more persistently and widely broadcast than its good qualities.

Its high moisture content makes it difficult to stock in any quantity in lump form. Increasing the use of Iowa coal outside of local markets must lie in the discovery of entirely new uses for it, in the discovery of new and better ways of burning it for power, industrial and domestic uses, in the devising of possible ways of storing it cheaply without deterioration in the size or quality, and without spontaneous combustion, or in devising treatments or processes which will enable it to be used in ways and for purposes now forbidden by its undesirable qualities.

TABLE II. PERFORMANCE OF IOWA COALS ON NATURAL DRAFT CHAIN GRATE STOKERS AT THE PLANT OF THE DES MOINES CITY RAILWAY CO. HAS BEEN CONSISTENTLY GOOD

No. of tests	5	6	24	12	7	9	1	1
Duration of tests hr.	107-1/2	152-3/4	713-3/4	289-1/4	162-1/4	197-1/4	21-1/4	19-3/4
Kind coal used	Iowa	Iowa	Iowa	Iowa	Iowa	Iowa	Iowa	Iowa
Water Evap. per lb. coal	5.90	6.47	6.24	6.22	6.52	5.93	6.68	6.63
Lb. coal burned per sq. ft. grate area per hr.	38.2	36.6	39.0	35.1	39.2	38.1	43.5	43.1
% Rating Developed	160.	176.	180.	162.	180.	169.	216.	215.
Efficiency of boiler furnace and grate	73.85	72.92	70.35	74.91	73.10	71.39	70.83	72.52
Analysis of coal A.F.								
% Moisture	16.53	16.51	14.82	16.31	16.99	16.64	13.31	15.53
% Ash	23.10	17.96	16.97	21.16	16.63	22.18	16.09	17.39
% Sulphur	4.20	5.23	4.87	5.15	4.11	4.36	5.20	4.24
B.t.u. per lb. as fired	8144.00	9034.00	9495.02	9435.00	9082.00	8478.00	9095.81	9316.62

Obsolescence, Formidable But Important

Ordinarily, the life of machinery is estimated as 10 yr. and the annual depreciation or "amortization" charge is 10 per cent of cost. Rapid change in equipment and methods may make the scrapping of machines necessary much sooner than 10 yr. if best economy is to be attained. Here enters "obsolescence."

What shall be the charge for this contingency? Will it be 3 or 4 or 6 yr. before a machine becomes obsolete? This is purely a matter of foresight, vision of future progress and improvement. It can be based somewhat on past experience but is liable to large errors. The safe way is to allow a generous charge for obsolescence based on past progress in the field and probable future developments. If the estimate is too large, no harm is done. If too low, calculated profits may be found to have vanished.

Lower prices for fuel oil are predicted if domestic output of crude is maintained. The output of crude is larger than last year and less is needed for cracking to meet gasoline requirements. So far, breaks in the petroleum and gasoline markets have not affected the price of fuel oil but accumulation of stocks is likely to bring reduction of prices.

Factors Affecting Operation of Pressure Gages†

BOURDON SPRING PRESSURE GAGES MAY BE RENDERED INACCURATE WITHIN THEIR LIMITS BY IMPROPER INSTALLATION, SHOCKS, HIGH PRESSURES AND SO ON. BY S. A. CURRY*

TOO MUCH confidence is often reposed in the readings of power house instruments without due consideration as to whether or not they have been put through proper tests for accuracy and dependability. Selection and use of power house meters, pressure gages, and other instruments of a type suitable for the desired purpose is of primary importance and should be followed with proper maintenance and frequent checking for accuracy, all of which may be influenced to some extent by the character and kind of service to which the instruments will be subjected and the purposes for which the instrument indications are obtained. Generally speaking if the necessity exists for the installation of an instrument, it should be installed and maintained to give only such indications as are within prescribed limits of error.

FIG. 1. MOVEMENT OF BOURDON SPRING IS TRANSMITTED TO INDICATOR THROUGH LINKS AND GEAR IN THE PRESSURE GAGE

The most common error experienced with most power house measuring and indicating instruments is the failure to check accurately at the time of installation, or, if this necessary precaution has been taken, the failure to follow up, with sufficient subsequent checking to insure against changes taking place. Many gages and meters, when first put in service, frequently go through a seasoning process that may cause changes in indications which require corrective adjustments.

Collection of data during the testing of power house equipment requires accurate work. It is essential, therefore, to use suitable test instruments, properly installed and accurately checked, and to know positively that correct indications are being obtained. Otherwise the results may be very misleading. The usual permanently-installed meters, gages and thermometers often selected and used for general and comparative purposes require only approximate accuracy and are not entirely suitable for obtaining accurate test data.

PRESSURE GAGES

Most gages used for measuring the pressures of steam, water and other fluids are of the Bourdon spring type, similar to that illustrated in Fig. 1. The Bourdon spring consists of a flat tube, usually of rolled steel or brass, bent in a semi-circular form as shown in the illustration. One end is attached to the bottom of the gage case with a projecting nipple for pipe attachment and the other end is free.

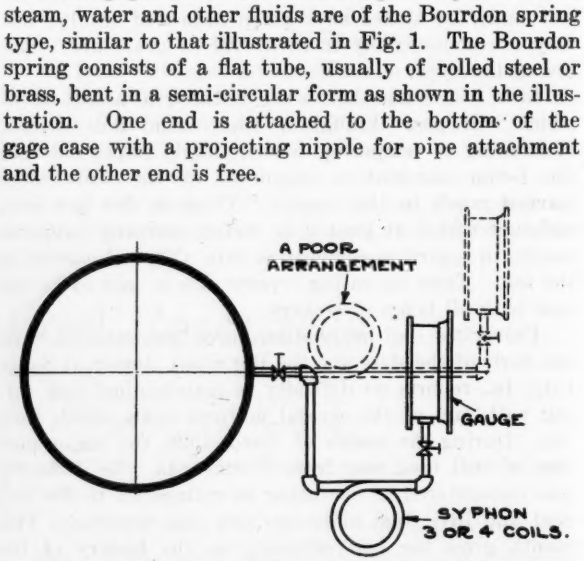


FIG. 2. PROPER METHOD OF CONNECTING PRESSURE GAGE. DOTTED LINES SHOW A POOR ARRANGEMENT

Any increasing change in pressure of the medium within the hollow-tube spring tends to straighten it, causing a movement of the free end. This movement is conveyed through a multiplying mechanism, consisting of links and a gear segment, to the indicator spindle, causing the spindle and indicator to revolve. The total movement of the free end of the Bourdon spring for the entire range of the gage is comparatively very small and is multiplied several times between the end of springs and gage dial. The existence of any improper conditions causing a movement of the spring or mechanism, other than that due to the pressure within the spring, will result in erroneous dial indications.

Some gages, designed as shown by the illustration, have the spring attached to the bottom of the gage case and the linkage mechanism mounted in a frame secured to the back of the case. Any distortion of the case will change the relative location of these two parts and, even though very slight, will cause unintentional movement of the indicator and incorrect indications.

Such distortions may be caused by the expansion of the back of the case if heated, as when located in the vicinity of hot steam pipes, or from stresses induced

*South Philadelphia Works, Westinghouse Electric and Mfg. Co.

†This is the first of a series of articles by Mr. Curry dealing with the construction, installation and operation of several types of instruments in use in every power plant. Although the instruments themselves are in common use, we believe that Mr. Curry presents information about them that will be new to many engineers, since it is seldom incorporated in textbooks, catalogs or other publications dealing with them. Subsequent articles will deal with barometers, mercury columns, manometers and various types of thermometers.

from pipe connections when the gage cases are secured in position, such as on a gage board. No matter how well the gage may have been checked, such conditions will cause unobserved errors of considerable magnitude. Gages designed with the linkage frame and spring support integral, with a single attachment to the case, are preferable.

High Temperatures Affect Indications

Bourdon springs of nearly all pressure gages are intended to be responsive to pressure only, but when subjected to any unduly high temperature the expansion due to the heating of the spring will cause a distortion, affecting the true indications of the gage. Therefore, it is necessary to protect the spring from any undue heating when used with a warm or hot medium. This is usually accomplished when the gage is used with steam, by placing pipe coils, sometimes termed "syphons," "pigtails," and so on, in the connecting pipe lines to entrap and hold cool water. Air is not dependable as it is liable to escape through pipe joints, valve stuffing-boxes, so that the hot steam cannot reach the gage. Care should be exercised to arrange such devices so that they never lose the entrapped water. Pipe coils should be located in the bottom of a loop or drop leg, with a valve, as shown in full lines in Fig. 2. Locating the coil as shown by the dotted lines is a poor arrangement, as the entrapped cool protective medium is liable to drain out and permit steam admission to the gage.

Coils made of two or more complete turns should be used. Globe valves are preferable to plug cocks as the latter cause too much trouble from leaks, possibly to the extent of allowing all of the entrapped cooling water to escape. Failure to protect properly the gage spring from overheating may not only cause the gage to give erroneous indications but, in cases where temperatures are high enough, may cause permanent set or injury to the spring.

Subjecting the gage spring to shocks, such as suddenly turning on a high pressure, or using the gage with pulsating pressures, subjects the gage to undue wear and may cause the gear segment to change its proper meshing with the pinion on the indicator spindle.

Most makers of the Bourdon spring type of gage specify that the gage should not be used with pressures higher than from 50 per cent to 75 per cent of the maximum range of the dial. Pressure above this set limit reduces the spring factor of accuracy and may cause permanent set or derangement of the spring.

It is also advisable, for the sake of accuracy, to avoid using the extreme lower range of the gage, as it is beyond the range for which the instrument was designed and built to give the best results. The actuating mechanism is not so sensitive or effective as at the higher ranges and slight errors of movement or play in joints cause errors of indication large in proportion to the true pressures.

The effect of the static head of a liquid entrapped in the gage pipe connection between the gage and the source of pressure should not be neglected, particularly when measuring low pressures or pressures when one or two pounds or more of error is considered an appreciable amount.

It is best, when possible, to mount gages close to and practically on a level with the connection at the source of pressure to avoid errors due to the static head of the entrapped liquid.

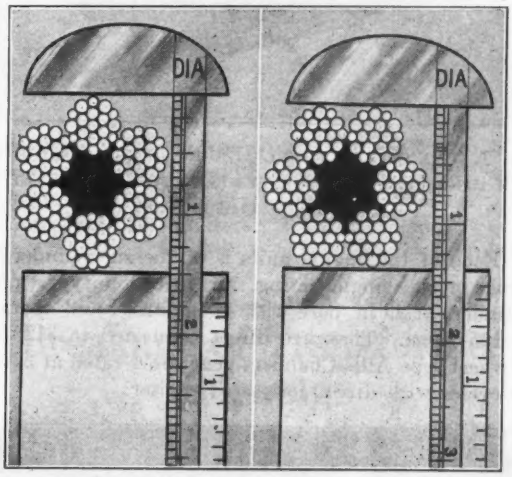
Particularly should this precaution be taken when measuring steam pressures, as often it is not possible to determine with certainty how much of the connecting piping is filled with water and how much with steam; there is also the possibility of having air entrapped, which, on account of the pipe feeling cool, may be credited as water.

For permanently installed gages, when the effect of the entrapped liquids is definitely known, the gage indicator may be set to compensate and have the gage read the true pressure.

How to Measure Wire Rope

THERE is only one correct way to measure wire rope and that is shown in contrast to the incorrect method by the accompanying illustration.

It is highly important that the proper size of rope



ILLUSTRATING BY CONTRAST THE CORRECT (LEFT) AND INCORRECT (RIGHT) METHOD FOR MEASURING WIRE ROPE

be employed since an undersized rope will not give the degree of service that should reasonably be expected, while an over-sized rope represents needless investment. More important, however, is to have the rope and the sheave properly fitted. No wire rope should be allowed to travel over a sheave wherein the groove is too small for the diameter of the rope. A pinching groove will do more damage to a wire rope in one hour than a properly sized groove in an entire week or more. Sheaves grooved $\frac{1}{16}$ in. larger than the diameter of the rope will lengthen the life of the rope many times as compared with rope life on pinching sheaves. Since sheaves are cheaper than good wire rope, there is small economy in continuing the operation of improperly grooved sheaves or drums.

Tread diameter of drums or sheaves also greatly affects wire rope life. Wherever possible, large diameter sheaves should be used, for the bending stresses are thereby reduced. Reverse bends should also be eliminated where possible since such reverse bending is wont greatly to diminish rope service. The photo was furnished through courtesy of the American Cable Co.

Diesel Engines of 3750 Hp. for Panama Canal

INCREASE IN SIZE AND EFFICIENCY OF DIESEL ENGINES AND USE OF SUCH UNITS FOR LARGE CENTRAL STATION SERVICE, OUTSTANDING TRENDS INDICATED BY PANAMA INSTALLATION

ALLOWING 10 per cent overload, which is guaranteed for a period of one hour by the Nordberg Mfg. Co. of Milwaukee, builders of the engines, the three oil engines recently installed at the Panama Canal represent a maximum combined capacity of 12,375 hp.

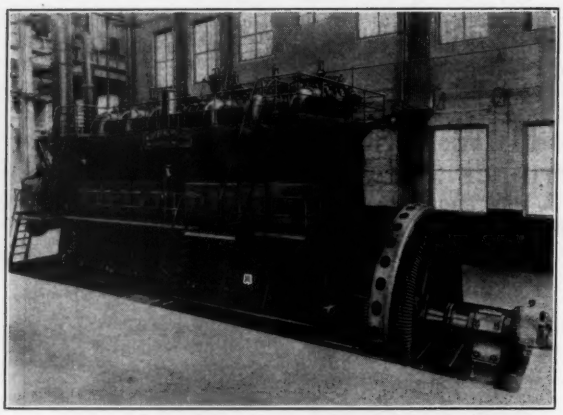


FIG. 1. ONE OF THE THREE 3750-HP. DIESEL ENGINES FOR THE PANAMA CANAL AS ASSEMBLED FOR TESTING AT THE PLANT OF THE BUILDER

Each of the engine units is of the six cylinder, two stroke cycle, single acting, air injection type, having cylinders of 29 in. bore with 44 in. stroke and operating at 125 r.p.m. They are direct connected to 3125-kv.a. flywheel type Allis-Chalmers generators rated at 2200 v., 25 cycles with direct connected exciter.

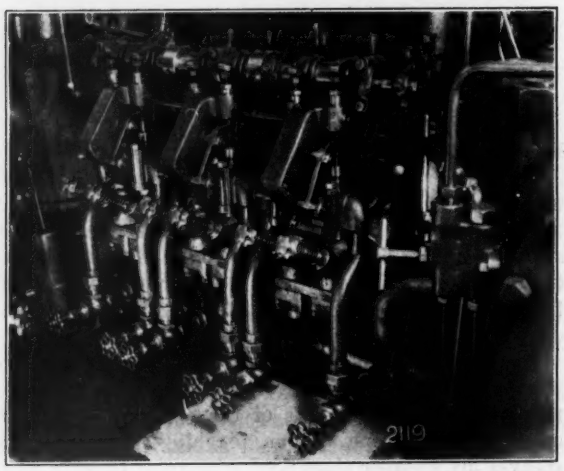


FIG. 3. SHOWING FUEL PUMPS WHICH ARE LOCATED OVERHEAD FOR CONVENIENCE OF INSPECTION AND CARE

On the end of the bedplate farthest from the generator the two double acting "V" type scavenging pumps are located. They are equipped with automatic plate valves and driven by a single crank at the end of the crank shaft. The cylinders are mounted on "A" frames which in turn are bolted to the bedplate. These frames are securely tied together at the back by the crosshead guides, on which slide slipper type crossheads. In addition to being bolted to the frames, each cylinder is bolted to the one adjoining it. Long through bolts anchored in the bedplate and extending to the top of the cylinders tie the bedplate, frames and cylinders together in the vertical direction. The crankshaft, which is constructed in four sections is 57½ ft. long.

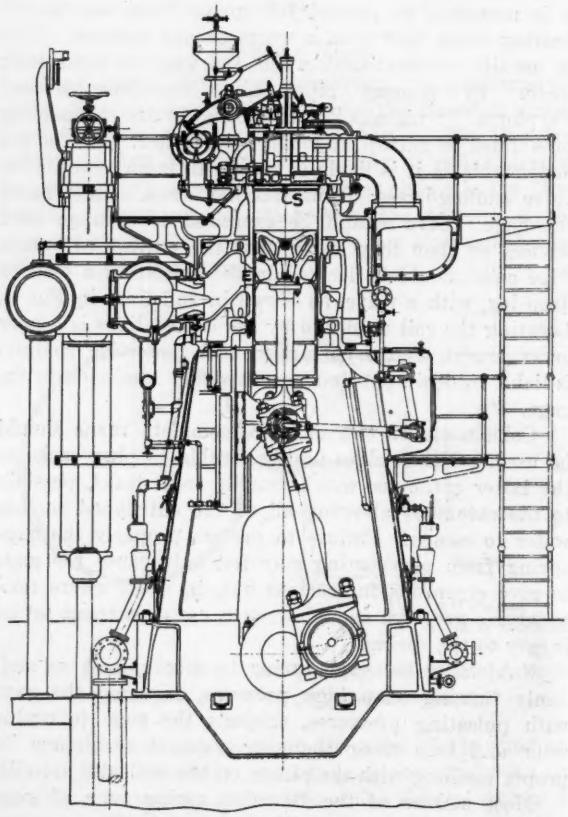


FIG. 2. SHOWING ENGINE DESIGN DETAILS, ADMISSION AND EXHAUST DUCTS AND INLET AND SCAVENGING VALVES

Starting is controlled from the overhead platform. Air at 1000 lb. pressure is used for both starting and injection purposes. Each cylinder has its own fuel pump. A constant volume is discharged at each plunger stroke but the amount delivered to the fuel injection valve is regulated by the governor which by-passes some of the fuel. The cam shaft is located at the top of the engine.

Both mechanical forced feed and circulating pressure are used in lubrication. After passing through the various bearings, the oil drains into the bedplate from which it is forced by a centrifugal pump through a duplex strainer into a storage tank where it is held under pressure. Before being again used by the engine, it is passed through a cooler which maintains constant oil temperature. Low grade fuel oil known as "Bunker

TEST DATA COVERING FIVE RUNS AT DIFFERENT LOADS

Percent of full load	25%	50%	75%	100%	110%
Duration-Min.	180	240	300	300	60
Barometer	29.79	29.79	29.79	29.79	29.79
Pressure-Injection Air	823.0#	974.0#	1030.0#	1070.0#	1075.0#
Pressure-Cooling Water	38.8#	38.8#	39.1#	39.0#	39.0#
Pressure-Lubr. Oil	19.3#	19.2#	18.5#	17.9#	18.5#
Pressure-Scavenging Air	5.16#	4.9#	5.0#	5.0#	5.1#
Temperature-Atmosphere	76.0°F	81.9°F	80.5°F	79.0°F	75.4°F
Temp.-Cooling Water Inlet	64.0°F	61.9°F	58.0°F	57.0°F	56.0°F
Temp.-Jacket Outlet	122.4°F	127.5°F	129.1°F	134.8°F	134.7°F
Temp.-Piston Cooling Outlet	124.2°F	126.3°F	127.4°F	127.6°F	129.3°F
Temp.-Lubr.Oil to Engine	84.2°F	85.7°F	84.1°F	83.0°F	82.0°F
Temp.-Lubr.Oil from Engine	99.5°F	101.5°F	102.1°F	103.0°F	103.4°F
Temp.-Exhaust	315°F	400°F	510°F	640°F	690°F
High Heat Value of Fuel	18738	18738	18738	18738	18738
Baume Gravity of Fuel at 60°	20.6	20.6	20.6	20.6	20.6
Viscosity at 122°F	47 sec.	47 sec.	47 sec.	47 sec.	47 sec.
Viscosity at 86°F	180 sec.	180 sec.	180 sec.	180 sec.	180 sec.
Sulphur Content	1.09	1.09	1.09	1.09	1.09
Fuel Oil # per hr.	584.0#	871.0#	1218.8#	1585.6#	1728.0#
Fuel Oil # per IHP hr.	.282	.277	.309	.322	.322
Fuel Oil # per BHP hr.	.618	.462	.431	.422	.417
IHP of Power Cylinders	2063.0	3150.0	3945.0	4925.0	5360.0
IHP of Air Compressor	171.6	212.4	236.3	250.2	249.9
IHP of Scav. Pump	387.5	385.0	376.2	386.0	395.0
BHP	943.0	1886.4	2825.0	3759.0	4143.1
Mean Indicated Pressure	37.28#	57.1#	71.45#	89.67#	97.4#
Mean Effective Pressure	17.08#	34.2#	51.2#	68.2#	75.1#
Mechanical Efficiency	45.8%	59.9%	71.6%	76.2%	77.2%
Thermal Efficiency	21.9%	29.4%	31.5%	32.2%	32.6%
Speed-R.P.M.	125.65	125.1	125.17	124.71	125.0

Lubricating Oil:
Gallons to Power Cylinders per 24 hours - 1.5
" " Scav. Pump & Compr. per 24 hours - 0.5
Average amount circulated through remainder of system, main bearings, crosshead, etc., - 1420 gallons per hour.

C'' and having a viscosity of not greater than 300 secs. at 122 deg. F. or 1100 secs. at 86 deg. F. is used as fuel. In order that such a heavy fuel can be passed through the fuel pumps, atomizers, etc., special heating appliances are provided.

Scavenging air is admitted to the cylinders at about 4½ to 5 lb. pressure through four poppet type valves in the cylinder head as shown at S in Fig. 2. The volume of air admitted is greatly in excess of the cylinder volume. All the air used passes through filters before use. Some of the air is drawn from below the generator, thus ventilating it. Exhaust is accomplished through ports shown at E in Fig. 2 which are located at the center of the cylinder liner. These ports are uncovered by the piston in the usual manner.

In addition to the usual water jackets of the cylinders, heads, air compressor, crosshead guides and exhaust manifold, the power pistons are also water cooled. All of the cooling water is filtered before use. Concrete mufflers provided with water spray at entrance and connected to concrete stacks extending for a considerable distance above the roof are provided for each engine.

To guard against damage, should either supply of

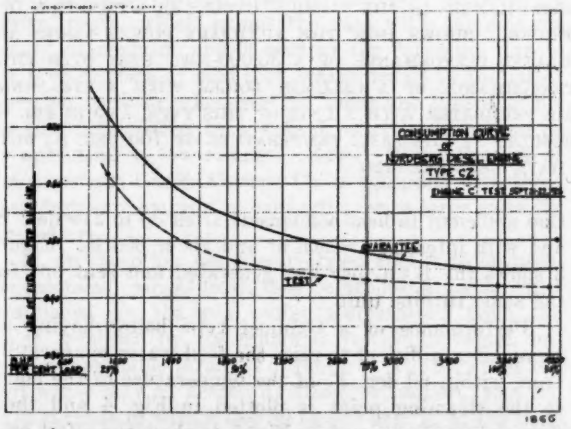


FIG. 4. CHART ILLUSTRATING FUEL CONSUMPTION UNDER DIFFERENT LOADS

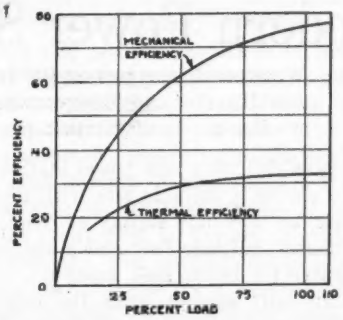


FIG. 5. THERMAL AND MECHANICAL EFFICIENCY CURVES SHOWING EFFECTIVE WORK DERIVED IN COMPARISON WITH THAT CONTAINED IN THE FUEL IN FORM OF HEAT, ALSO CONSUMED IN FRICTION AND CARRIED AWAY BY COOLING WATER, EXHAUST GASES AND RADIATION

cooling water or lubrication fail, provision is made to shut the engine down quickly by cutting off the fuel supply automatically when the pressure of either cooling water or lubricating oil drop below normal.

Test data obtained from complete tests made before shipment are tabulated herewith and shown graphically in Figs. 4 and 5.

In order to comprehend the size of this engine the following dimensions are given: Overall length of engine alone, 48½ ft.; width of bedplate, 11 ft.; height of engine above floor, 21 ft.; crankpin diameter, 19½ in.; crosshead pin diameter, 12 in. The weight of the engine alone is 815,000 lb.; that of the crankshaft 90,000 lb.

Breakage of Transformer Bushings

CRACKS in the porcelain of transformer bushings are often due to solid bus bars being rigidly connected to the terminals of bushings, transformer field engineers of the General Electric Co. have pointed out.

Bus copper may easily be subjected to a range in temperature from —10 deg. to 110 deg. F., or a 120-deg. range, which means an eighth of an inch linear expansion for every 10 ft. of bus. A range of 150 deg. is common in some localities, with a 3/16-in. expansion for every 10 ft. of bus.

If a bus between two bushings, or between rigid connections to the station framework, is straight, an expansion of ⅛ in. would crack the porcelains. If, on the other hand, the busses are not straight, calculations will show whether or not the included bends of such heavy bus material will relieve the bushings from the strain.

Copper tubing, either straight or curved, has the same characteristics as solid bars, and with a few companies it is standard practice to include a short extra-flexible section in any such bus connection to relieve strain from bushings.

FIFTY-FOOT sheet steel piling jetted full length in a sand bottom was used on the Mississippi River at Brainerd, Minn., to protect the power house which was located on sand and had started to show signs of failure.

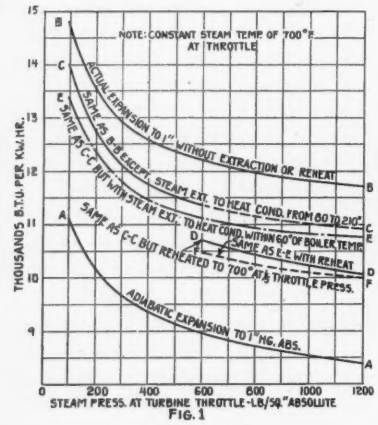
Modern Power Stations Use High Pressures

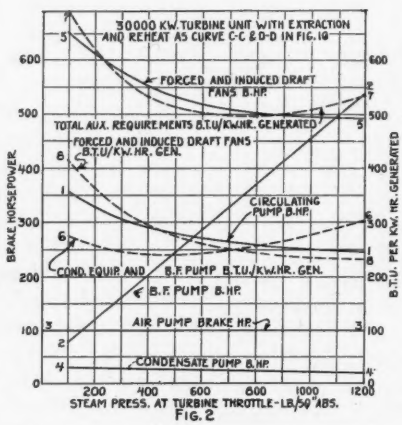
WORKING PRESSURES OF 600 LB., NOW COMMON IN MIDDLE WEST, MAKES USE OF BOTH AIR HEATER AND ECONOMIZER PRACTICAL EVEN WHEN FEED WATER IS BROUGHT TO BOILER TEMPERATURE IN STEAMING TYPE ECONOMIZER. BY F. S. COLLINGS*

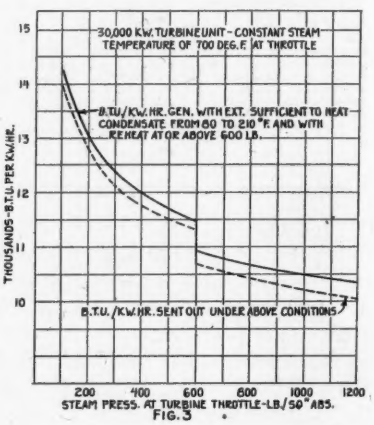
WHEN PLANNING a new power station it is necessary to choose a suitable site with necessary railroad facilities, an adequate supply of circulating water for the condenser, suitable fuel and a source of reasonably good water for boiler feed make up. Selection of the main unit will depend upon the existing station load, the anticipated load, the load factor, the capacity factor over a period of say three years and the planned ultimate capacity.

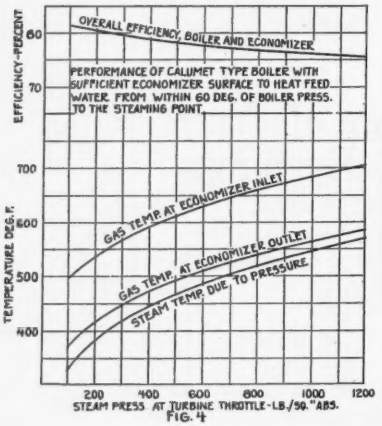
Next the question of steam pressure must be considered and 500 to 600 lb. has become more or less standard pressure for the larger stations. Calculations to determine the most economical pressure are shown graphically in Figs. 1 to 6. Figure 1 has been prepared to show the effect of pressure on the heat economies of the various cycles at a constant steam temperature of 700 deg. F. Power required by motor-driven auxiliaries of a 30,000-kw. turbine unit operating with different steam pressures and a constant steam temperature of 700 deg. F. at the throttle are plotted in Fig. 2 on the basis of both horsepower and B.t.u. per kw. generated. The turbine is operated in each case with steam extraction sufficient to heat condensate from 80 to 210 deg. F. and with interstage reheat at and above 600 lb. Figure 3 shows the B.t.u. per kw. generated and sent out for the same turbine unit.

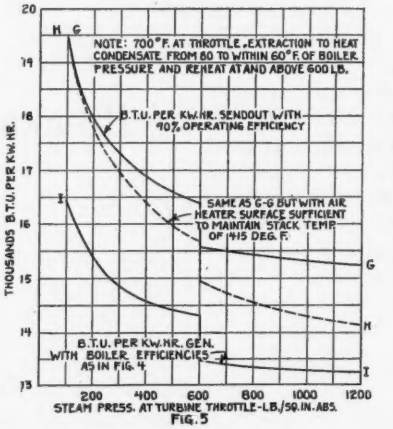
Performance of a Calumet type boiler having an economizer sufficient to raise the feed water temperature from within 60 deg. F. of the temperature of the boiler to the steaming point is plotted in Fig. 4 and these figures have been used in Fig. 5 to show the effect on a system using this boiler, steam extraction and reheat.

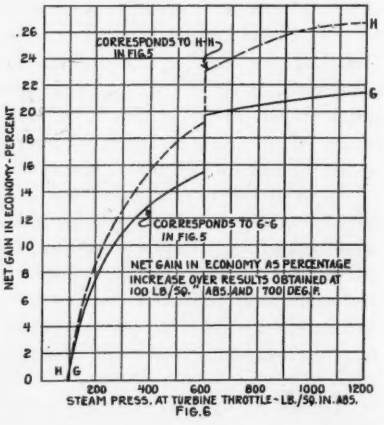

NOTE: CONSTANT STEAM TEMP. OF 700°F. AT THROTTLE
ACTUAL EXPANSION TO 1" WITHOUT EXTRACTION OR REHEAT
SAME AS B-B EXCEPT, STEAM EXT. TO HEAT COND. FROM 80 TO 210°
SAME AS C-C BUT WITH STEAM EXT. TO HEAT COND. WITHIN 60° OF BOILER TEMP.
SAME AS C-C BUT REHEATED TO 700° AT ½ THROTTLE PRESS.
ADIABATIC EXPANSION TO 1" HG. ABS.
THOUSANDS B.T.U. PER KW. HR.
STEAM PRESS. AT TURBINE THROTTLE-LB./SQ." ABSOLUTE
FIG. 1


30000 KW. TURBINE UNIT WITH EXTRACTION AND REHEAT AS CURVE C-C & D-D IN FIG. 1
FORCED AND INDUCED DRAFT FANS B.HP.
TOTAL AUX. REQUIREMENTS B.T.U./KW.HR. GENERATED
FORCED AND INDUCED DRAFT FANS B.T.U./KW.HR. GEN.
CIRCULATING PUMP B.HP.
COND. EQUIP. AND B.F. PUMP B.T.U./KW.HR. GEN.
B.F. PUMP B.HP.
AIR PUMP BRAKE HP.
CONDENSATE PUMP B.HP.
BRAKE HORSEPOWER
B.T.U. PER KW. HR. GENERATED
STEAM PRESS. AT TURBINE THROTTLE-LB./SQ" ABS.
FIG. 2


30,000 KW. TURBINE UNIT - CONSTANT STEAM TEMPERATURE OF 700 DEG. F. AT THROTTLE
B.T.U./KW.HR. GEN. WITH EXT. SUFFICIENT TO HEAT CONDENSATE FROM 80 TO 210 °F. AND WITH REHEAT AT OR ABOVE 600 LB.
B.T.U./KW.HR. SENT OUT UNDER ABOVE CONDITIONS
THOUSANDS - B.T.U. PER KW. HR. GENERATED
STEAM PRESS. AT TURBINE THROTTLE-LB./SQ" ABS.
FIG. 3


OVERALL EFFICIENCY, BOILER AND ECONOMIZER
PERFORMANCE OF CALUMET TYPE BOILER WITH SUFFICIENT ECONOMIZER SURFACE TO HEAT FEED WATER FROM WITHIN 60 DEG. OF BOILER PRESS. TO THE STEAMING POINT
GAS TEMP. AT ECONOMIZER INLET
GAS TEMP. AT ECONOMIZER OUTLET
STEAM TEMP. DUE TO PRESSURE
EFFICIENCY - PERCENT
TEMPERATURE DEG. F.
STEAM PRESS. AT TURBINE THROTTLE-LB./SQ." ABS.
FIG. 4


NOTE: 700° F. AT THROTTLE - EXTRACTION TO HEAT CONDENSATE FROM 80 TO WITHIN 60° F. OF BOILER PRESSURE AND REHEAT AT AND ABOVE 600 LB.
B.T.U. PER KW. HR. SENDOUT WITH 90% OPERATING EFFICIENCY
SAME AS G-G BUT WITH AIR HEATER SURFACE SUFFICIENT TO MAINTAIN STACK TEMP. OF 315 DEG. F.
B.T.U. PER KW. HR. GEN. WITH BOILER EFFICIENCIES AS IN FIG. 4
THOUSANDS B.T.U. PER KW. HR.
STEAM PRESS. AT TURBINE THROTTLE-LB./SQ. IN. ABS.
FIG. 5


CORRESPONDS TO H-H IN FIG. 5
CORRESPONDS TO G-G IN FIG. 5
NET GAIN IN ECONOMY AS PERCENTAGE INCREASE OVER RESULTS OBTAINED AT 100 LB./SQ." ABS. AND 700 DEG. F.
NET GAIN IN ECONOMY - PERCENT
STEAM PRESS. AT TURBINE THROTTLE-LB./SQ. IN. ABS.
FIG. 6

FIGS. 1—6. CURVES IN FIG. 1 SHOW THE EFFECT OF PRESSURE CHANGES IN THE VARIOUS CYCLES AS A FUNCTION OF PRESSURE AT A CONSTANT TEMPERATURE OF 700 DEG. F. FIGURE 2 SHOWS HOW THE AUXILIARY POWER VARIES AS THE PRESSURE INCREASES WHILE FIG. 3 SHOWS THE CALCULATED PERFORMANCE OF A 30,000-KW. UNIT OVER THE SAME PRESSURE RANGE. FIGURE 4 IS THE CALCULATED PERFORMANCE OF A CALUMET BOILER WITH A STEAMING TYPE ECONOMIZER, FIG. 5 SHOWS THE EFFECT OF USING AN AIR PREHEATER WITH A UNIT OF THIS TYPE, AND IN FIG. 6 THE GAIN IN EFFICIENCY WHICH MIGHT BE EXPECTED OVER RESULTS AT THE SAME TEMPERATURE OF 700 DEG. F., BUT AT 100 LB. PRESSURE, HAVE BEEN PLOTTED

*Mech. Eng., Sargent & Lundy, Inc. From paper read at A.S.M.E. Regional Meeting, Kansas City.

Curve H-H on this figure indicates the additional gain due to the addition of an air preheater to bring the exit gas temperature to 415 deg. F. At 1200 lb. this amounts to about 1125 B.t.u. per kw. or about 7.4 per cent. Net gain in economy over 100 lb. and 700 deg. F. operation are shown in Fig. 6 where the effect of the air preheater is again noticeable.

Final Analysis Shows 600 Lb. Most Economical Pressure

In the final analysis in which investments and operating charges are balanced against thermal efficiency, it is apparent that a working pressure of 600 lb. offers the best return on the invested dollar at this time. This is true even of the direct expansion turbine while the additional gains due to reheating at, or slightly above, that point in the expansion curve which approaches saturation at the normal expected load, is from 4½ to 6 per cent according to the turbine characteristics. It has been a matter of surprise to the pioneers in the reheat field that the interstage reheater justified its investment charges over a wide unit load range.

That the regenerative cycle will be used for feed water heating may be taken as a matter of course but, in considering the steam extraction characteristics of the main unit, the obvious question is: At what temperature may the air for combustion be admitted to the stoker or the pulverized fuel equipment? If it is to be limited to say 300 deg. F. in order to avoid undue strain and deterioration in a chain grate stoker, then a water economizer followed by a relatively small air heater is indicated.

Fin Type Cooler May Be Used to Temper Heated Air

In such a case it is advisable to limit the regenerative feed water heating to a value which will insure an adequate return on the economizers. As an alternative, the gas-heated water economizer may be omitted, an air heater of sufficient surface to reduce the boiler outlet gas to the desired stack temperature installed and a fin-tube air cooler placed in the air outlet duct from the air heater in order to temper the air to the stoker requirements.

This air cooler uses boiler feed water at a fairly low temperature point in the cycle as a circulating medium and, when arranged with a suitable bypass, affords a very convenient and flexible method of regulating the temperature of the air to the stoker. This arrangement also has the advantage that the air-cooler surfaces are always clean, which is not the case with the flue-gas heated economizer, and it escapes the corrosion due to the precipitation of acid soot, which occurs in the latter when on bank or whenever the tubes are chilled below the dew-point either by low feed water temperatures or by operating at low ratings. Exeter Power Station of the American Gas & Electric Co. is equipped with these secondary economizers in connection with large capacity air heaters.

If, on the other hand, pulverized fuel is to be used, the secondary air, at least, may be preheated to the limit established by the gas outlet temperature from the boiler, qualified by the economic restriction which imposes a reasonable terminal difference. In this event the feed water may be heated by steam extraction from the main turbine to within say 50 to 100 deg. F. of the boiling point corresponding to the pressure.

In this connection it should be noted that the reheat turbine lends itself particularly well to this latter cycle, for the reason that steam is available at the high pressure cylinder exhaust at a pressure high enough to correspond to a temperature of from 300 to 400 deg. F. in the average case, while at the same time it is at, or even below saturation, according to the load.

Radiant heat surface in the furnace emphasizes a factor which the use of high pressures had already brought to the front, that is, the use of evaporators for boiler feed makeup. The multiple effect low heat level evaporator has been in use for a number of years and has long since justified its installation when either bad water, high steam pressure or combination of the two are concerned. Recently the tendency has been to install the evaporator in unit form, rather than as a central water treating plant.

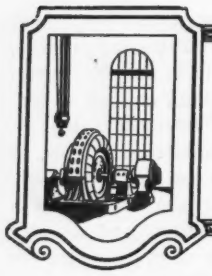
Unit Evaporator Systems Offer Advantages

In other words, a single or double effect evaporator is being made an integral part of the regenerative feed water system of each main unit. It is flexible as to heat level and pressure range, it utilizes extracted steam as a heating agent, and the applied heat may be all recovered except for that lost in the blow-down and by radiation. It is a low-priced piece of equipment, requiring no additional pumps except for re-circulation and no special condenser, as the vapor from the last effect is used to supplement extracted steam in one of the low pressure stage heaters. This heater requires no additional surface, as the evaporator should be run off peak as fast as practicable, under which condition extraction pressure and flow are below normal.

Before leaving the feed water system, mention should be made of the generator air cooler and deaeration of boiler feed water. The closed system of generator air cooling with external fans and either single stage or two stage water cooling has become standard at this time. The latter system is more expensive and involves more piping than the former while the heat recovered by the turbine condensate reduces the low pressure extraction by a corresponding amount and, therefore, does not present any improvement in economy.

There is considerable difference of opinion on the part of operating engineers as to the relative merits of the closed feed water system and of the flash system of deaeration. The former requires closer attention to the physical condition of the plant while the latter, where the separator is the last step in the feed water system before the boiler feed pump, allows more margin in the physical condition of the plant. Both systems are in use at the Crawford Avenue Station, and the results indicate that they are equally satisfactory when given the necessary attention.

In a 600-lb. plant where the saturated steam temperature due to the pressure is 500 deg. F., it is quite practicable and economical to raise the temperature of the feed water from 375 deg. F. to 450 deg. F. in a steel tube economizer. This 75 deg. rise would be equivalent to a decrease in outlet gas temperature of about 187 deg. F. and would involve a reasonably small amount of surface. If, furthermore, an economizer of the steaming type is used, as at Crawford Avenue, the water may be raised to the boiling point of 500 deg. F. in the economizer.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Sectionalizing Circuits in Case of Trouble

A Description of the Operating Procedure Used by a Large Power Company to Isolate Damaged Sections of Their Distribution System. By Vernon W. Palen

JUST HOW FAR systematized primary sectionalizing practice extends is unknown. At any rate, a surprisingly small amount of material on the subject has appeared in print. It is, therefore, with the hope

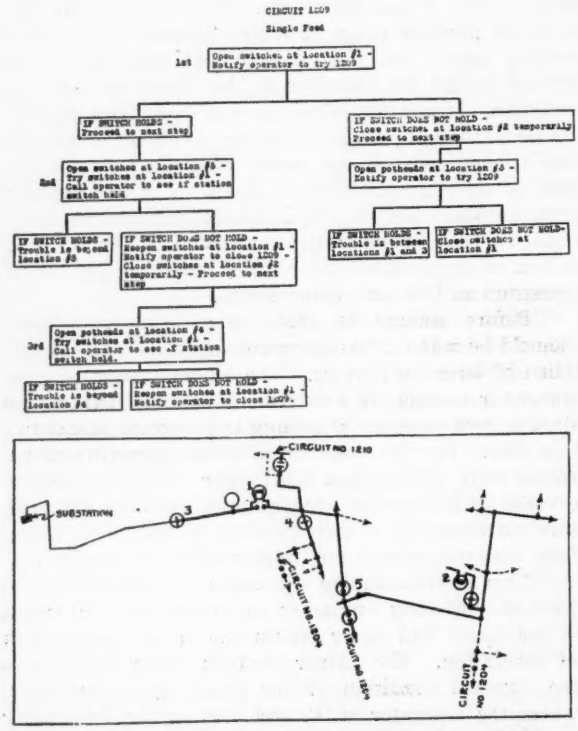

CIRCUIT 1209
Single Feed
1st
Open switches at location #1 - Notify operator to try 1209
IF SWITCH HOLDS - Proceed to next step
IF SWITCH DOES NOT HOLD - Close switches at location #2 temporarily Proceed to next step
2nd
Open switches at location #3 - Try switches at location #1 - Call operator to see if station switch holds
Open potheads at location #5 - Notify operator to try 1209
IF SWITCH HOLDS - Trouble is beyond location #3
IF SWITCH DOES NOT HOLD - Reopen switches at location #1 - Notify operator to close 1209 - Close switches at location #2 temporarily - Proceed to next step
IF SWITCH HOLDS - Trouble is between locations #1 and 3
IF SWITCH DOES NOT HOLD - Close switches at location #1
3rd
Open potheads at location #4 - Try switches at location #1 - Call operator to see if station switch holds.
IF SWITCH HOLDS - Trouble is beyond location #4
IF SWITCH DOES NOT HOLD - Reopen switches at location #1 - Notify operator to close 1209.
CIRCUIT NO 1210
SUBSTATION
CIRCUIT NO 1209
CIRCUIT NO 1204
CIRCUIT NO 1204

FIG. 1. TYPICAL SINGLE FEED CIRCUIT (NO. 1209)

of benefiting others that the writer "passes along" an eastern company's methods for primary sectionalizing.

Perhaps the best way to begin is with illustrations. Three representative circuits are shown. They are, respectively, the single feed (circuit No. 1209), the loop (circuit No. 2252), and the double loop (circuit No. 4207-4208).

The various symbols used on the diagrams to represent sectionalizing devices are as follows:

Potheads—Illustrated on circuit No. 1209 at location 3.

Manual Oil Switches (installed in transformer room)—Illustrated on circuit No. 1209 at location 1.

Manual Oil Switches (installed on pole)—Illustrated on circuit No. 1209 at location 5.

Automatic Oil Switches (installed in transformer room)—Illustrated on circuit No. 4207-4209 at location 1.

Automatic Oil Switches (installed on pole)—Illustrated on circuit No. 4207-4208 at location 2.

Other symbols used on the diagrams are:

Consumer's transformer room—large circle.

Pole—small circle.

*Express primary (no local load)—indicated by light line.

*Locally loaded primary—indicated by heavy line.

**Single or two phase primary—indicated by dash line.

**Three phase primary—indicated by solid line.

On the sectionalizing instruction sheets the captions: "If the Switch Holds" and "If the Switch Does Not Hold" should be understood to mean respectively: "If the Station Circuit Breaker Holds" and "If the Station Circuit Breaker Trips."

Circuit diagram No. 1209 illustrates a typical single feed circuit. The diagram shows at a glance the size and extent of the underground and overhead primary and the location of all sectionalizing points (indicated by the larger numbers 1, 2, 3, etc.). Since all of the substation feedouts of this particular company are underground, it is only necessary to follow the cable route (on the diagram) to the first pole. This, therefore, is the point where underground primary ends and where overhead primary begins. On circuit No. 1209, this point is at location 3.

Study circuit No. 1209 further. Suppose a short circuit occurs, and the station breaker trips out. The substation operator opens the disconnect switch, closes the breaker, and then the disconnect switch. If the breaker again trips out the operation is repeated two more times. If the breaker trips out the third time the operation is repeated at fifteen minute intervals although the operator immediately turns to the sectionalizing instructions for locating the trouble.

Theoretically, primary testing may begin from the substation and proceed outward or vice versa. From a practical standpoint, however, the situation is changed.

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*On circuit No. 1209 there are no consumers between the substation and location 3; therefore, this is designated "express primary" and is shown by a light line.

**Applies to circuits where all three phases of the primary are shown on one map (circuits No. 1209 and No. 4207-4208). Where the phases are shown separately (circuit No. 2252) all lines are solid.

Sections of underground cable are almost invariably tested first because nine times out of ten trouble occurs in the underground cable.

The first step in sectionalizing routine would ordinarily be to open the circuit at location 3. Again the theoretical disagrees with the practical in that the circuit is opened at location 1. Due to the fact that the If the breaker does not hold the substation operator instructs the troubleman to close the switches at location 2 which restores service (through a tie to circuit No. 1210) to all consumers except those between locations 1 and 3.

The troubleman is now instructed to open the potheads at location 3 (for the time being the operator

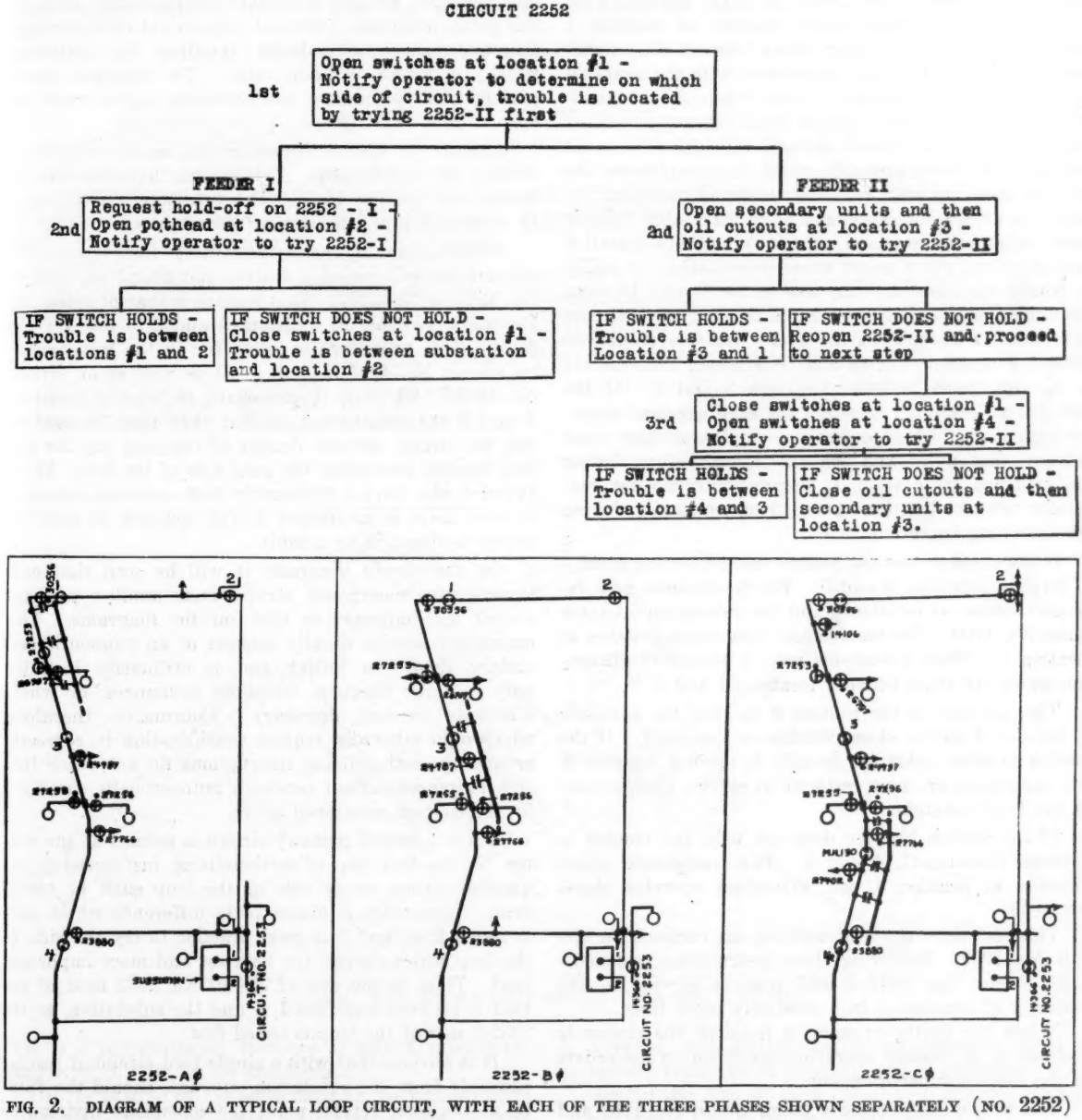

CIRCUIT 2252
1st
Open switches at location #1 - Notify operator to determine on which side of circuit, trouble is located by trying 2252-II first
FEEDER I
2nd
Request hold-off on 2252 - I - Open pothead at location #2 - Notify operator to try 2252-I
IF SWITCH HOLDS - Trouble is between locations #1 and 2
IF SWITCH DOES NOT HOLD - Close switches at location #1 - Trouble is between substation and location #2
FEEDER II
2nd
Open secondary units and then oil cutouts at location #3 - Notify operator to try 2252-II
IF SWITCH HOLDS - Trouble is between Location #3 and 1
IF SWITCH DOES NOT HOLD - Reopen 2252-II and proceed to next step
3rd
Close switches at location #1 - Open switches at location #4 - Notify operator to try 2252-II
IF SWITCH HOLDS - Trouble is between location #4 and 3
IF SWITCH DOES NOT HOLD - Close oil cutouts and then secondary units at location #3.
2252-A#
2252-B#
2252-C#
CIRCUIT NO. 2253

FIG. 2. DIAGRAM OF A TYPICAL LOOP CIRCUIT, WITH EACH OF THE THREE PHASES SHOWN SEPARATELY (NO. 2252)

station operator is making the circuit alive at fifteen minute intervals, potheads are dangerous and it is desirable to avoid their manipulation whenever possible. This procedure makes it necessary to open the potheads at location 3 only when the trouble occurs in the section between location 1 and the substation.

When the troubleman has the switches open at location 1 he telephones the substation and the substation operator tries circuit No. 1209 (as described previously). discontinues trying the circuit at fifteen-minute intervals). With potheads open at location 3 the substation operator again tries circuit No. 1209. If the switch holds, the trouble is between locations 1 and 3 and service has been restored to all consumers but those in the area where the fault occurred.

On the contrary, if with the potheads open at location 3, circuit No. 1209 is tried and the breaker does not hold, the trouble is between location 3 and the sub-

station. The troubleman is instructed to close switches at location 1, thereby restoring service to all consumers (since there are no consumers between substation and location 3).

Returning to location 1 (with switches open), should the breaker hold, the troubleman opens switches at location 5 (avoiding potheads at location 4 for reasons aforementioned) and closes switches at location 1. The sectionalizing instructions are a bit unusual here in that the troubleman closes switches at location 1 (without cutting the primary dead between the substation and location 1). This procedure, with the usual oil switches would be dangerous since there is the possibility of feeding directly into a fault. Such a condition would overtax the rather limited capacity of the oil switches and would probably result in an explosion. In this instance, however, no such danger is imminent because the switches at location 1 are a very much heavier type (with high overload capacity) and are installed only at points where ample space is available. (Usually in transformer rooms.) In testing the section between locations 1 and 5 it is preferable to close the switches at location 1 because in the event that the trouble is beyond location 5 service will be restored immediately to all consumers between locations 3 and 5. If the switches at location 1 were not the high overload capacity type it would be necessary to cut the primary dead between that point and the substation, before closing the switches at location 1, thereby interrupting consumers between locations 1 and 3 unnecessarily during the switching operation.

If the breaker does not hold at the station the trouble is between locations 1 and 5. The troubleman now reopens switches at location 1 and the substation operator closes No. 1209. The troubleman then closes switches at location 2. These operations restore service to all consumers except those between locations 1 and 5.

The last step in the routine is to open the potheads at location 4 and to close switches at location 1. If the station breaker holds the trouble is beyond location 4. All consumers are now restored to service except those in the faulty section.

If the station breaker does not hold the trouble is between locations 1, 4 and 5. The troubleman opens switches at location 1 and substation operator closes No. 1209.

This completes the sectionalizing instructions for circuit No. 1209. Following these instructions systematically locates the trouble and restores service to the majority of consumers in a relatively short time.

When the faulty primary is repaired the circuit is restored to its normal operating condition on the orders of the district superintendent.

The writer has purposely taken circuit No. 1209 and analyzed it in detail because it is simple and because the principles underlying its sectionalizing scheme also form the backbone of the schemes for more complicated circuits.

Circuit No. 2252 illustrates a typical loop circuit. In this case, there are manually operated switches at location 1; the usual practice is to install automatic switches at the mid-point of the loop thereby automatically opening it at the center when a fault occurs. The difference in the sectionalizing instructions (whether automatic or manual switches are used at the mid-point) is slight. The difference may be seen by comparison of sectionalizing instructions for circuits No. 2252 and No. 4207-4208.

Circuit No. 2252 also illustrates the method of showing the three phases separately when banked secondaries are met with in sectionalizing. When opening the primary switches at location 3 on circuit No. 2252 it is first necessary to open secondary sectionalizing units at this point, otherwise a current path would exist through the transformer secondaries shunting the switches, which, of course, is undesirable. The diagram shows plainly that secondary sectionalizing units must be opened only on B phase.

Circuit No. 4207-8 illustrates the most complicated circuit, the double loop. This circuit, however, can be broken up into two loops. The two loops can, in turn, be separated into four single feed circuits.

Examination of the sectionalizing instructions for this circuit will reveal a feature not found on circuits No. 1209 or No. 2252. This feature is that of using the automatic switches at locations 1 and 2 to test for the fault. This procedure is called for in the instructions on circuit No. 4207-II (5th step) as well as on circuit No. 4208-I (4th step) the automatic switches at locations 1 and 2 are constructed so that they may be used to test the circuit without danger of tripping out the station breaker protecting the good side of the loop. These switches also have a sufficiently high overload, capacity so that there is no danger to the operator in case the switch is closed in on a fault.

On the circuit diagrams it will be seen that consumers with emergency service from another primary circuit are indicated as such on the diagrams. This emergency service usually consists of an automatic secondary throwover switch and is ordinarily installed only in large theatres, telephone exchanges, or where otherwise deemed necessary. Consumers, therefore, who would otherwise require consideration in correctly arranging sectionalizing instructions do not enter into this matter when their service is automatically cared for by the method mentioned above.

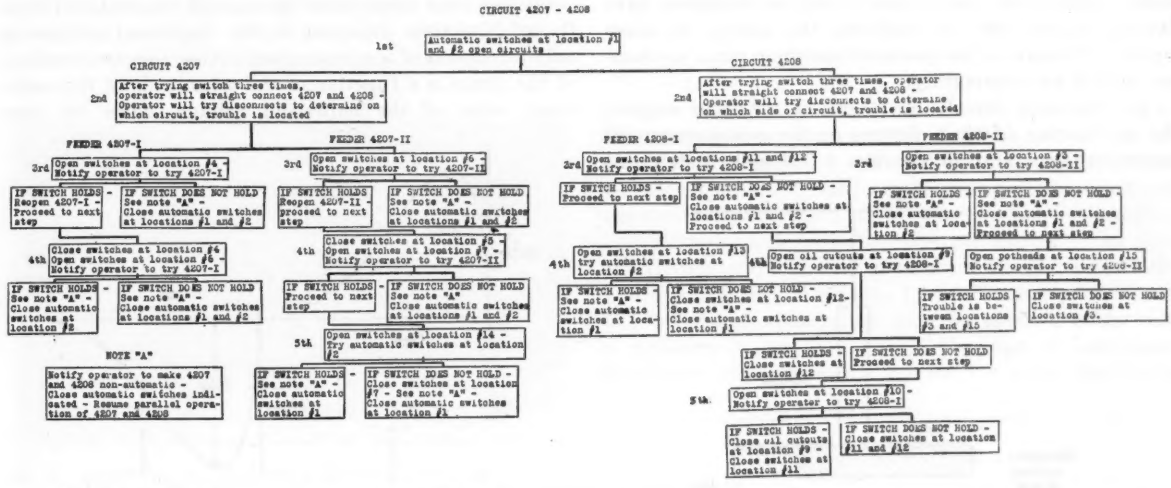
When a looped primary circuit is opened at the center (in the first step of sectionalizing instructions) the question arises which side of the loop shall be tested first. Seemingly, it makes little difference which side is tested first, but it is good practice to try the side of the loop which carries the heaviest and more important load. Thus, in the case of circuit No. 2252 most of the load is between locations 1, 4 and the substation, so the 2252-2 side of the loop is tested first.

It is obvious that with a single feed circuit if testing proceeds from the substation outward, should the fault be at the most remote point the consumers distributed between this point and the substation would be interrupted each time a new section is tested. This is very undesirable, of course, and is avoided by having an available tie with another primary circuit as shown on circuit diagram No. 1209 (location 2). When such a tie exists, therefore, after the underground cable is tested, it is best to proceed with the testing from the most remote section inward to the substation.

Thus, if the section between locations 5 and 2 (circuit No. 1209) tests satisfactorily its load may be picked

up by closing switches at location 2. Further, if the section between locations 1 and 5 tests satisfactorily its load may be picked up by closing switches at location 5.

As mentioned previously in this paper, the manipulation of potheads, under load is always dangerous. It is for this reason that the sectionalizing instructions usually carry a phrase "Request hold-off" preceding directions to open or close potheads. This means, to open the station disconnect switch and to leave it open until further notice is received from the troubleman.


CIRCUIT 4207 - 4208
1st
Automatic switches at location #1 and #2 open circuits
CIRCUIT 4207
CIRCUIT 4208
2nd
After trying switch three times, operator will straight connect 4207 and 4208 - Operator will try disconnects to determine on which circuit, trouble is located
FEEDER 4207-I
FEEDER 4207-II
FEEDER 4208-I
FEEDER 4208-II
3rd
Open switches at location #6 - Notify operator to try 4207-I
Open switches at location #6 - Notify operator to try 4207-II
Open switches at locations #11 and #12 - Notify operator to try 4208-I
Open switches at location #3 - Notify operator to try 4208-II
IF SWITCH HOLDS - Reopen 4207-I - Proceed to next step
IF SWITCH DOES NOT HOLD - See note "A" - Close automatic switches at locations #1 and #2
IF SWITCH HOLDS - Reopen 4207-II - proceed to next step
IF SWITCH DOES NOT HOLD - See note "A" - Close automatic switches at locations #1 and #2
IF SWITCH HOLDS - Proceed to next step
IF SWITCH DOES NOT HOLD - See note "A" - Close automatic switches at locations #1 and #2 - Proceed to next step
IF SWITCH HOLDS - See note "A" - Close automatic switches at location #2
IF SWITCH DOES NOT HOLD - See note "A" - Close automatic switches at location #2 - Proceed to next step
4th
Close switches at location #4 - Open switches at location #6 - Notify operator to try 4207-I
Close switches at location #8 - Open switches at location #7 - Notify operator to try 4207-II
Open switches at location #13 try automatic switches at location #2
Open oil cutouts at location #9 - Notify operator to try 4208-I
Open potheads at location #15 - Notify operator to try 4208-II
IF SWITCH HOLDS - See note "A" - Close automatic switches at location #2
IF SWITCH DOES NOT HOLD - See note "A" - Close automatic switches at locations #1 and #2
IF SWITCH HOLDS - Proceed to next step
IF SWITCH DOES NOT HOLD - See note "A" - Close automatic switches at locations #1 and #2
IF SWITCH HOLDS - See note "A" - Close automatic switches at location #1
IF SWITCH DOES NOT HOLD - See note "A" - Close automatic switches at location #1
IF SWITCH HOLDS - Trouble is between locations #3 and #15
IF SWITCH DOES NOT HOLD - Close switches at location #3.
5th
Open switches at location #14 - Try automatic switches at location #2
IF SWITCH HOLDS - Close switches at location #12
IF SWITCH DOES NOT HOLD - Proceed to next step
Open switches at location #10 - Notify operator to try 4208-I
NOTE "A"
Notify operator to make 4207 and 4208 non-automatic - Close automatic switches indicated - Resume parallel operation of 4207 and 4208
IF SWITCH HOLDS - See note "A" - Close automatic switches at location #1
IF SWITCH DOES NOT HOLD - Close switches at location #7 - See note "A" - Close automatic switches at location #1
IF SWITCH HOLDS - Close oil cutouts at location #9 - Close switches at location #11
IF SWITCH DOES NOT HOLD - Close switches at location #11 and #12

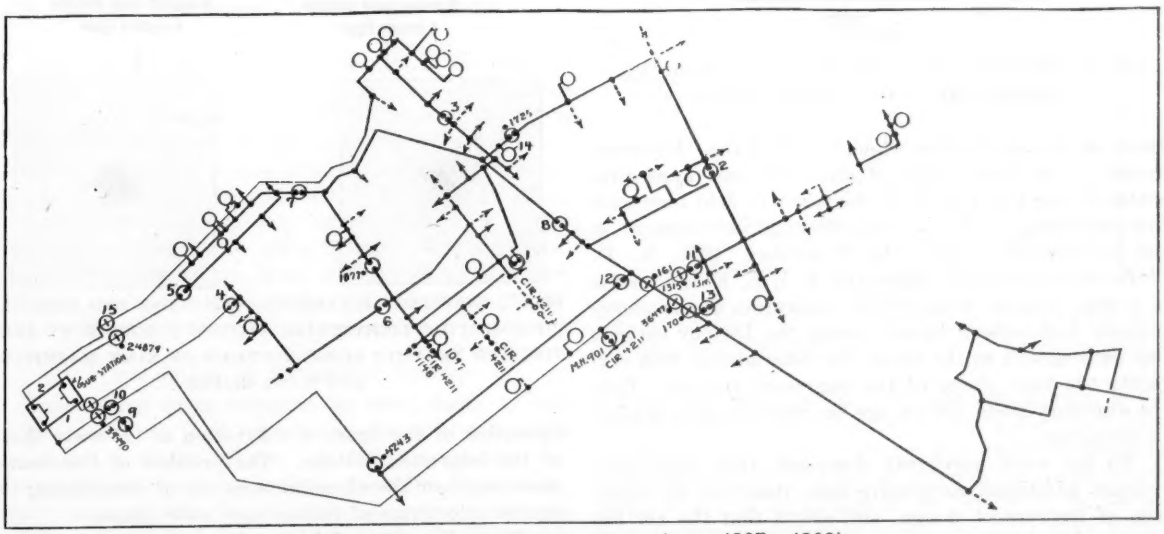


FIG. 3. THE DOUBLE LOOP CIRCUIT (NOS. 4207—4208)

This is a precautionary measure to guard against endangering the life of the troubleman.

On the bottom of the sectionalizing instruction sheet appears the date (or dates) of issuance. Many times slight changes (not affecting the instructions) need to be made on the diagrams. In these cases the instruction sheet is redated to agree with the date on the new diagram. Whenever changes affecting the instructions are made on the diagram it is necessary, of course, to change the instruction sheet to agree with the new conditions.

Summing up the foregoing, this company has found that in sectionalizing primary circuits to locate trouble and restore service to all consumers at the earliest possible moment, it is good practice:

On all circuits to:

1. Test primary cable first.
2. Avoid manipulation of potheads whenever possible.
3. Arrange sectionalizing instructions to restore service first to consumers who due to size of establishment or nature of work will be most handicapped by a prolonged shutdown.

On single feed circuits to:

1. Proceed with testing (after underground cable is tested) from end of primary toward substation picking up the load of each tested section from outside primary tie as explained previously.

On single loop circuits to:

1. Open loop at center, proceed with testing from center of loop toward substation, picking up load of each tested section from "good" half of the loop. (Similar to method explained previously for single feed circuits.)

On double loop circuits to:

1. Proceed with testing as on single loop circuits, explained above.

Measurement of Surges on Transmission Lines

Lichtenberg Figures, What They Are and How They Are Used in the Investigation of Voltage Surges on Transmission Lines.

By Everett S. Lee and C. M. Foust*

IN 1777, IN GERMANY, Dr. G. C. Lichtenberg described a number of experiments in which he caused peculiar figures to be made in sulphur dust by means of a charged electrode. A little over 100 yr. later, in 1888, two other investigators, Trouvelet and Brown, showed how these figures could be produced on a photographic plate. Since that time several other investigators have devoted much time to studying the nature of these figures, although at the present time their exact mechanism is still an uncertainty.

It remained for J. S. Peters in 1924 to suggest the application of these figures to the measurement of surge voltages and to develop a suitable instrument

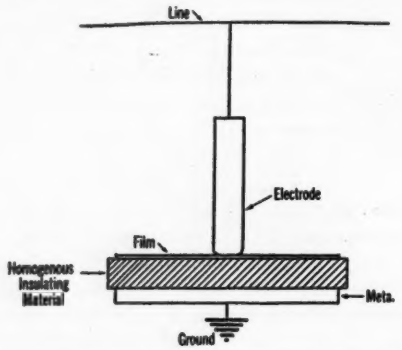


FIG. 1. ARRANGEMENT OF ELEMENTS FOR PRODUCING PHOTOGRAPHIC LICHTENBERG FIGURES

based on this application which he called the "Klydonograph." In June, 1925, Messrs. Cox and Legg presented before the A. I. E. E. the result of field tests with this instrument and described extended development in the instrument design. In September, 1926, K. D. McEachron presented before the A. I. E. E. the results of a most detailed study of the calibration of the photographic Lichtenberg figures, using the Dufour cathode ray oscillograph as the means for determining with certainty the wave shape of the impressed voltage. Thus the discovery made 150 yr. ago has recently been applied to advantage.

To the work previously described, this paper contributes additional correlative data, describes an extension of instrument design, and shows that the art has advanced to a stage where surge voltages on transmission lines in the order of 2,000,000 v. may be recorded with a reasonable degree of accuracy.

As now used, the Klydonograph or surge voltage recorder, consists of an electrode bearing upon the emulsion side of a photographic film or plate, which rests on the smooth surface of a piece of homogeneous insulating material as shown in Fig. 1. If the electrode is connected to the line side of a circuit and the insulation connected to the ground side through a metal plate, and a positive surge voltage of say 20 kv. maximum is impressed from line to ground, a positive figure as shown in Fig. 2 will be found on the photographic film after development. If, with the same connections, a negative surge voltage of say 20 kv. maximum is impressed from line to ground, a negative figure as shown in Fig. 2 will be found on the photographic film after development.

It has been found that figures will be produced even though the time duration of the impressed voltage is only a fraction of a microsecond. Also, the size (radius) of the figure is a function of the magnitude of the maximum value of the impressed voltage, while the configuration of the figure is a function of the wave shape of the impressed voltage. The problem of the instrument engineer therefore becomes one of deciphering the figures into terms of voltage and wave shapes.

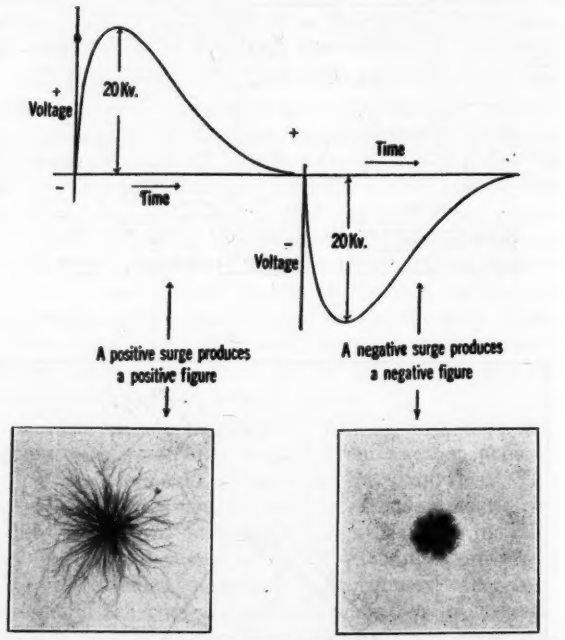


FIG. 2. SHOWING APPEARANCE OF POSITIVE AND NEGATIVE PHOTOGRAPHIC LICHTENBERG FIGURES PRODUCED BY POSITIVE AND NEGATIVE SURGE VOLTAGES OF SAME MAGNITUDE AND WAVE SHAPES

The calibration of Lichtenberg figures for a given instrument to determine magnitude of voltage is obtained by impressing voltages of different values and observing the size of the resulting figure. This can be done for as wide a range of wave shapes as are available. To do this it is necessary, of course, to know accurately the voltage and the wave shape of the impressed impulse. In the process of calibrating such an instrument, the magnitude of the voltage is easily measured by means of a sphere spark gap. The determination of the wave shape, however, is a far more difficult matter and, until recently, could not be made with any degree of accuracy. The development of the Dufour cathode ray oscillograph placed at the disposal of the scientist a means for determining the wave shape of an impulse

*Both of the General Engineering Laboratories, General Electric Co., Schenectady, N. Y. An abstract of a paper presented at the winter convention of the A. I. E. E., New York, February, 1927.

with marvelous accuracy, and this instrument was used in the calibration of the Lichtenberg figures described in this article. The surge voltages were impressed from sections of a 500-kv. rectifying type lightning generator. The wave shape varied from ½ cycle of a sine wave at 60 cycles (wave shape No. 1) to surge voltages rising to their maximum value in two microseconds (wave shape No. 2) and in four microseconds (wave shape No. 3).

Figure 3 shows a set of positive and negative figures for 5, 10, 15 and 20 kv. taken with wave shape No. 2. It is from such figures as these that the calibration curves are obtained. The radius of a positive figure is measured from the figure center to the most distant streamer.

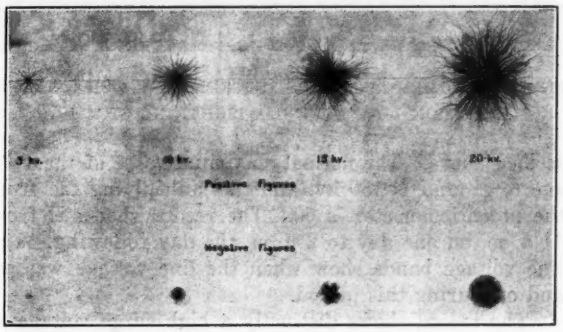


FIG. 3. POSITIVE AND NEGATIVE LICHTENBERG FIGURES FOR DIFFERENT VOLTAGES. (WAVE SHAPE NO. 2.)

Referring to the table, it is seen that the average deviation from the means for 100 figures on the three wave shapes investigated at the different voltages is within, plus or minus, 15 per cent, while the maximum deviation from the means is in the order of plus or minus 30 per cent. It appears that an accuracy of 25 per cent can be reasonably expected on any single measurement made with these figures. Where several figures of somewhat the same size are obtained under different conditions, the agreement of these among themselves permits a more exact interpretation.

Wave Shape of Impressed Voltage

In studying surge voltages, the wave shape, as well as the magnitude is of importance, for on this depends the duration of the voltage. At the present time the determination of the wave shape from the Lichtenberg figure characteristics is not as definite or as certain as the determination of the magnitude from the figure size and herein there is room for added study. At the present time the figures recorded with unknown wave shapes can be compared with figures recorded with known wave shapes as determined by cathode ray oscillograph. This allows prediction of the time duration to within a general order, but not with the exactness required.

From Fig. 3 it is clearly evident that the negative figures are quite inferior to the positive figures for purposes of voltage measurement, since for a given voltage they are less than half the size of the positive figure. It has also been shown that the negative figures present a greater deviation for differing wave shapes. There is also another serious objection which is when the instrument with a moving film is connected to a transmission line with normal voltage continuously impressed the width of the band produced by the line voltage is enough to hide negative surges up to values as high as 2.3 times normal line voltage and to give uncertainties to values somewhat above this. This would result in erroneous conclusions as regards the number of negative figures reported.

To overcome these objections, Mr. Foust conceived the idea of connecting two recorders in parallel with the connections of one opposite from that of the other, thus insuring a large positive figure for every surge. Referring again to Figs. 1 and 2, the results of directly connecting the recorders to the line are shown. If, however, the recorder is connected oppositely, that is the electrode to ground and the metal plate to line, the positive surge will record a negative figure and the negative surge will record a positive figure.

If an instrument is made up with two recorders, one connected directly, and one connected oppositely, as shown in Fig. 4, then all surges, positive or negative, can be measured from the positive figures. The type of Klydonograph shown in diagram in Fig. 1 is of the stationary type. With this type of instrument, a new film or photographic plate must be inserted every time a discharge is recorded. With the type of instrument developed for commercial service for measuring surge

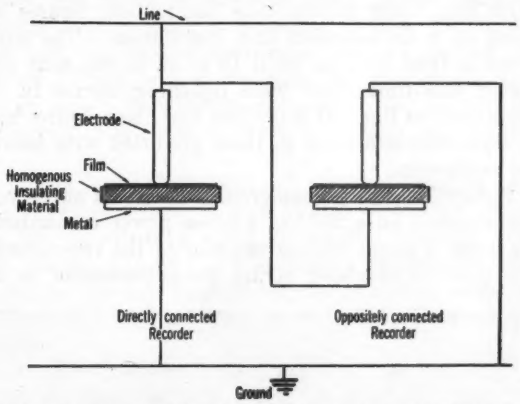


FIG. 4. ARRANGEMENT OF ELEMENTS FOR PRODUCING BOTH POSITIVE AND NEGATIVE FIGURES FOR ANY SURGE VOLTAGE

voltages on transmission lines, the arrangement is virtually the same, but instead of having a stationary plate or film, a continuously moving film passes between the electrode and the plate below. One of the recent instruments is driven by a clock at the rate of ½ in. per hr. so as to give a continuous record for eight days, timing is obtained by photographing the hour numbers on the film.

Because of the high voltage circuits to which this instrument is sometimes applied, some provision must be made for connecting the instrument to the transmission line up to values where the normal maximum voltage to ground is 180 kv., and where the maximum values of surface may be ten times this value. Of the various schemes proposed for direct connection, that shown in Fig. 5 has been recently used in 27 installations and has been found simple, reliable and easy to calibrate. The instrument is connected in parallel across several insulators of an insulator string with added protection over the line insulation as desired. The instrument is placed in a sheet metal housing equipped with

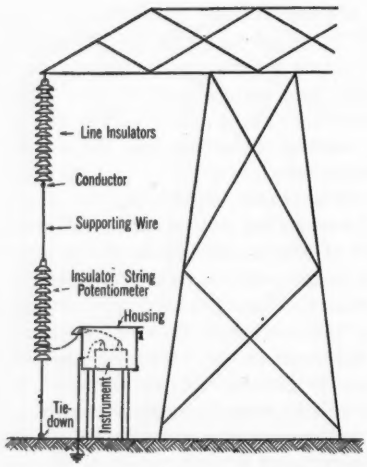


FIG. 5. ARRANGEMENT FOR CONNECTING SURGE VOLTAGE RECORDER INSTRUMENT TO TRANSMISSION LINES

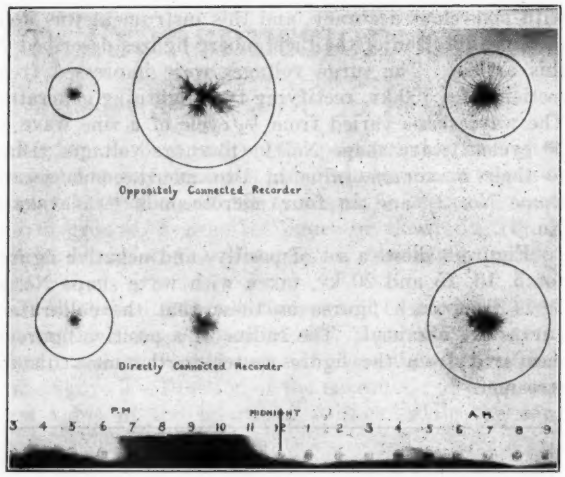


FIG. 7. SPECIMEN RECORD OF SURGE VOLTAGES ON A TRANSMISSION LINE DURING A LIGHTNING STORM

suitable entrance bushings and automatic grounding device when the door is open. The housing protects the instrument from the weather and insures safety against tampering.

Specimen Field Records

In Fig. 6 are shown some Lichtenberg figures obtained on a transmission line installation. The surge record is from 3 p. m. until 10 a. m. of the next day. During this time there were lightning storms in the vicinity of the line. It is obvious that these figures have the same characteristics as those produced with laboratory equipment.

Figure 7 shows a photographic record of surge voltages obtained on a 200-kv., 3-phase power transmission line using a surge voltage recorder of the two recorder type with an insulator string potentiomometer as described above. The normal maximum value of the voltage to ground is 180 kv. and the multiplying factor of the potentiomometer is 60. The record shown is from 11 a. m. on one day to 2 p. m. the day following. The line voltage bands show when the line voltage was off and on during this period.

The record shows distinctly a high surge voltage at 4:20 p. m. on Friday, and the weather report indicates severe lightning in the vicinity of the installation at this time. The loss of the line voltage band some 30 min. before the surge shows that the line was deenergized at 3:50 p. m. A close examination of the original film reveals a surge at 4:03 p. m., but this is not distinguishable from the print. The figure obtained at 4:20 p. m. on the oppositely connected recorder is a positive "slip" and therefore represents a voltage of

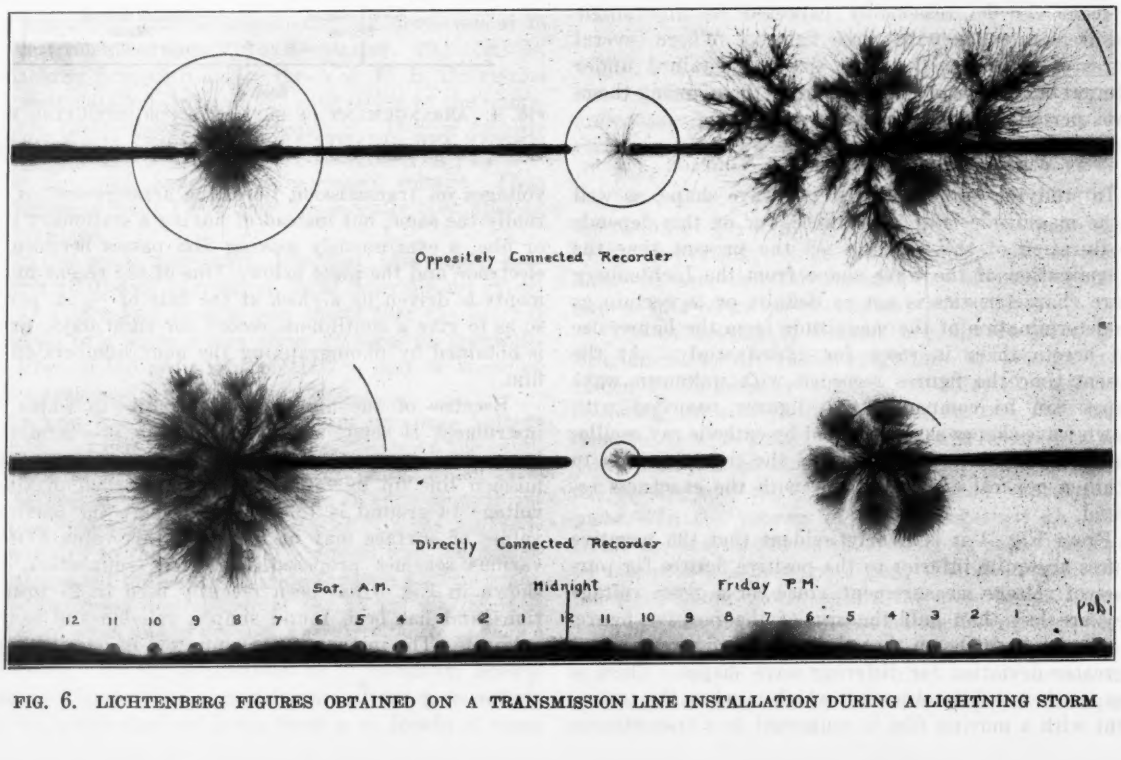

Oppositely Connected Recorder
Directly Connected Recorder
Sat. A.M.
Midnight
Friday P.M.
12 11 10 9 8 7 6 5 4 3 2 1 12 11 10 9 8 7 6 5 4 3 2 1

FIG. 6. LICHTENBERG FIGURES OBTAINED ON A TRANSMISSION LINE INSTALLATION DURING A LIGHTNING STORM

negative polarity on the instrument of between 25 kv. and 35 kv. Using a potentiomometer multiplying factor of 60, these figures represent a surge voltage on the line of from 1500 to 2100 kv. The corresponding figure on the directly connected recorder is predominently negative. Since some positive figure characteristics are discernible on the directly connected recorders, however, the surge must have been oscillatory and of a highly damped nature, with a first half cycle of negative polarity and the second positive polarity in very much lower voltage.

At 10:30 p. m. on the same day another surge was recorded. A lightning storm was in progress at this time and the line excitation had been removed about 15 min. before this surge. Positive figures were obtained on both recorders. The figure on the oppositely connected recorder indicates an initial half cycle of negative polarity of 780 kv. The figure on the directly connected recorder indicates the second half cycle to be of positive polarity of 270 kv. The weather records for Saturday morning show another lightning storm in progress. The surge records reveal two surges, one at 8:11 a. m. and the other at 8:18 a. m., the line having been deenergized at 8:11 a. m. From the print, these two surges are not so clearly distinguished, though from the original film, the record is clear. The figure obtained at 8:11 a. m. on the directly connected recorder is of positive characteristics and the oppositely connected recorder of negative characteristics. The line surge was, therefore, unidirectional and positive in polarity. The figure on the directly connected recorder is a positive slip, therefore indicating a line voltage of between 1500 and 2100 kv.

CALIBRATION OF POSITIVE PHOTOGRAPH LICHTENBERG FIGURES

60-Cycle Wave Shape—Wave Shape No. 1

Kv. impressed (max. values)	Number of figures	Positive figures average radius mm.	Average deviation from mean. Per cent plus and minus	Maximum deviation from mean. Per cent plus and minus
5	35	10.3	12	45
10	34	19.0	5	16
15	36	24.3	5	15
20	36	30.2	8	37
24	31	35.6	5	12 disregarding slips 125 regarding slips

Two-Microsecond Wave Front—Wave Shape No. 2

4	29	10.6	9	25
7.2	39	11.9	22	60
10	36	16.3	10	35
16.6	36	22.8	10	26
23.2	36	30.4	5.5	19
27.6	37	40.3	14	26

Four-Microsecond Wave Front—Wave Shape No. 3

5.95	36	11.8	12	41
10.75	35	18.3	6.5	20
16.7	36	25.3	5.3	15
25.6	36	36.4	6.2	24

Average Deviation For All of Above Wave Shapes

Kv. impressed (max. values)	Number of figures	Average deviation from the mean. Per cent plus and minus	Maximum deviation from the mean. Per cent plus and minus
5	100	13.7	32
10	105	8.5	31
15	108	7.2	28
25	104	10.2	33

Public Utility Burns Wood Waste

DESIGNED to absorb all wood refuse from the sawmill of the White Pine Lumber Co., at Bernalillo, N. Mex., the new power plant of the Federal Light & Traction Co. will be put in operation about June 1. This plant will act to a certain extent as standby to the present Albuquerque steam station and the stokers will be built to burn either coal or sawdust with means provided for instantaneous change over from wood to coal.

Steam will be supplied at 400 lb. 160 deg. superheat by a 900-hp. Springfield boiler stokered by a M. A. Hofft Co. National stoker capable of operating the boiler at 200 per cent rating on hogged fuel containing 50 per cent moisture. The induced draft fan will be located in the base of the Prat-Daniel Corp. Venturi stack, while a forced draft fan will be used to put the air for combustion through the air preheater into the furnace.

Electric power will be generated by a Westinghouse turbine rated at 3750 kv.a. at 5000 ft. elevation. A step-up transformer bank, installed adjacent to the turbine room, will consist of three 1000-kv.a. transformers with supplementary water cooling coils to boost the transformer rating 50 per cent when desired. Supplementary water cooling is necessary because of the altitude and the high temperatures reached during the summer. Transformers are connected in Y on the high voltage side with a grounded neutral and supply Albuquerque 18 miles from town, by a 44-v. transmission line.

As the low voltage side of the transformers may later be changed from 2400 to 4150 volts, tertiary windings are installed to avoid circulating current. The high voltage side of the transformer is supplied with two to five per cent undervoltage steps and an extended winding of 2 to 5 per cent steps with mechanical tap changers.

Condensing water is supplied from the lumber mill log pond, supplemented, when necessary, by the flow through the large irrigation ditch, the water from the ditch being returned after going through the condenser.

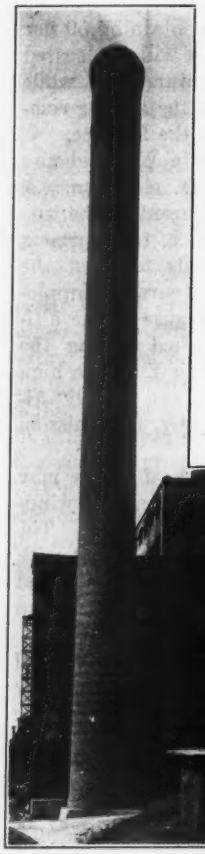
Electric Clock as a Desirable Load

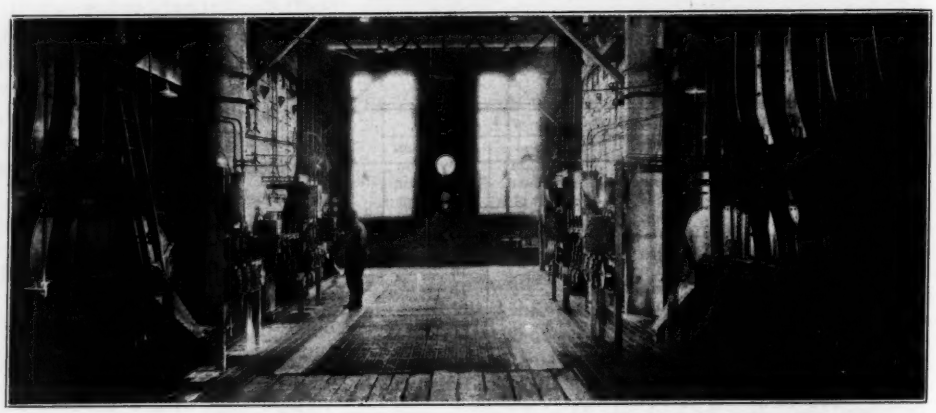
AMONG THE many uses to which electricity may be put in the home, office or factory, a comparatively new one is the electric clock. Public Service Electric and Gas Co. has just approved the policy of connecting clocks to its alternating current service. These clocks are operated by small motors which run in synchronism with the company's alternating current supply system. The clocks may be connected to socket or convenience outlet and will run and keep accurate time within a few seconds quite automatically, being regulated by a master clock in the power station, which is checked with the Arlington radio time signals and which regulates the frequency of the alternating current system. In case of an interruption to the electric system, the usual clock of this kind will stop and must thereafter be set by hand when the service is restored but some models are provided with a spring, kept constantly wound, which is depended on to carry the clock movement along in the event of a break in the electric light service.

Paper Mill Installs New Boiler Plant

CAREFUL ANALYSIS OF STEAM PRESSURES, AVAILABLE HYDRO-ELECTRIC POWER AND VARIOUS FUELS DETERMINE DESIGN OF PLANT OF CANADIAN INTERNATIONAL PAPER CO. AT THREE RIVERS, QUEBEC. BY A. H. WHITE* AND H. E. KLEFFEL†

AT THE CONFLUENCE of the St. Lawrence and St. Maurice Rivers, 80 mi. below Montreal, is located the Three Rivers mill of the Canadian International Paper Co. This mill is now producing over 650 t. of news print a day, thus making it the largest paper mill now operating. One of the outstanding features is that it is one of the few totally electrically-equipped paper mills now in operation. The first section of the mill, approximately one-half the capacity of the present mill, was provided with a boiler plant containing eight 478-hp. boilers, fired with oil. At the time of this installation, oil could be obtained at a relatively low price compared with coal and this fact warranted the construction of an oil fired plant.





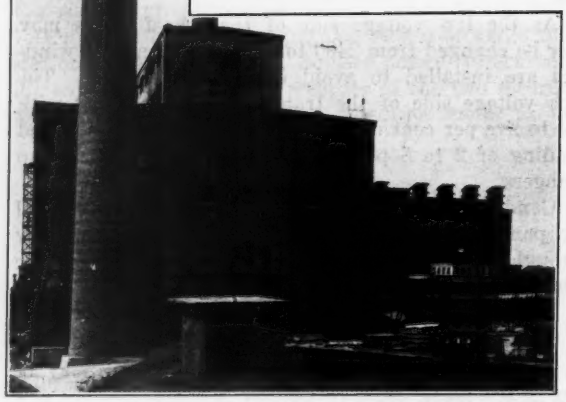


FIG. 1. NEW BOILER HOUSE, LOOKING WEST, SHOWING NEW STACK IN FOREGROUND AND TRESTLES AT RIGHT CARRYING COAL TRANSPORT PIPES FROM PREPARATION HOUSE

FIG. 2. CONVENIENT GROUPING OF CONTROL BOARDS ENABLES ONE OPERATOR TO HANDLE FOUR BOILERS. FORCED DRAFT BURNERS ARE USED, WITH FEEDERS ON THE FLOOR ABOVE

From 1920 to 1925 the price of fuel oil increased so much that consideration of the fuel burning equipment for an extension of the present plant, or for a new plant, warranted an exhaustive study of the available fuels and relative cost and also of the various types of fuel burning equipment that could handle the various fuels available. This investigation disclosed the fact that at Three Rivers three other large paper mills were burning different coals: the first burned anthracite buckwheat coal on forced draft traveling grates; the second Nova Scotia coal on British throw-type stokers with Lancashire boilers and the third, West Virginia bituminous coal on chain grates and multiple-retort underfeed stokers.

SEVERAL TYPES OF COAL ARE AVAILABLE

The nearest and most logical sources of coal supply to Three Rivers are in the Maritime Provinces of Canada, whence coal can be shipped by ocean steamship directly to the paper mill. These coals have a fairly high heat value, and are free burning, long flame coals with high sulphur and fairly low ash content. The lower grades, however, have ash with a softening point as low as 1800 deg. F., and usually contain a large percentage of iron causing them to clinker and run. Due to its high sulphur content, this coal must be stored carefully in order to eliminate storage pile fires.

Other coals available at Three Rivers are West Virginia and Pennsylvania bituminous coals received direct by ocean steamships from the Atlantic seaboard; also Western Pennsylvania and other American coals by lake steamship and barge from the Great Lakes direct to the company's mill. It was also deemed advisable that, in case of a failure in the coal supply due to strikes or other causes, provision should be made to revert to oil, the present mill being provided with a large capacity oil storage. Based on economy and the necessity for burning a wide range of bituminous coals in conjunction with the possible use of fuel oil, it was decided to install pulverized fuel burning equipment.

The first half of the present mill is equipped with four paper machines electrically driven, each being supplied with power from a steam turbine operating at an inlet pressure of 125 lb., with 100 deg. of superheat and exhausting at 5 to 10 lb. pressure into the paper

*Chief Engineer, International Paper Co., New York.
†Engineer, McClellan and Junkersfeld, Inc., New York.

machine for drying. It was decided to install similar turbo-generator drive equipment for the four new paper machines. This determined the operating steam pressure and superheat of the boiler plant, namely 135 lb., 100 deg. superheat.

Studies were made on the design of a 400-lb. and 600-lb. high pressure boiler plant with non-condensing turbines, exhausting at 125 lb. pressure for supplying the individual paper machine turbo-generators, utilizing this turbine exhaust at 5 to 10 lb. for paper drying, the main high pressure turbine exhaust also being used for digesters. This and other studies on a high-pressure boiler and turbine plant indicated that cheap by-product power could be generated by this method. On the other hand, hydro-electric power is available at this plant at relatively low cost and provides the energy for driving the major portion of the equipment through the mill. This available, low-cost 24-hr. hydro-electric power, together with other operating factors, favored the 135-lb. installation, which was selected.

It was decided to erect the new boiler plant on a site covering part of the present boiler plant and adjacent to the present oil storage tanks and proposed raw coal storage pile. It was also decided to build a separate preparation plant, as space was not available at the boiler plant site on account of the present oil storage tanks and other buildings.

Two movable coal towers are located on the wharf for unloading coal from boats. These towers discharge on a traveling belt, which discharges to a cross belt delivering the coal to an initial pile; this is distributed over the 110,000-t. coal storage space by two drag scrapers. In addition a track hopper is provided for handling coal car delivery. The coal in storage is reclaimed by drag scrapers.

The preparation plant is located between the coal storage and the St. Lawrence River wharf and alongside a railroad siding. Coal from the raw coal bunkers passes through individual 6-t. steam-grid, gravity-type, driers, into the 6-t. mills. Each mill cyclone discharges into a duplicate screw conveyor system carrying the powdered coal to one end of the plant, discharging into duplicate powdered coal weigh-bins, each of which discharges to a fuel transport pump. The two powdered fuel transport pumps, one of which is of sufficient capacity to supply the powdered coal under normal operating conditions, are interconnected to duplicate 5-in. fuel transport pipes, which run a horizontal distance of approximately 600 ft. and vertically a distance of 100 ft. to the powdered coal bunkers in the boiler plant. The preparation plant is provided at present with five dryers and mills, with room for one additional unit. It is equipped with dryer exhauster fans and a dust collecting system together with air compressors for supplying air for powdered fuel transport.

Up to the present Pennsylvania slack coal and Nova Scotia slack coal have been prepared at this plant with only minor operating difficulties, the principal ones being the hanging-up of the fine Pennsylvania slack coal in the dryers. It has also been found desirable to install small air heater elements for heating the circulating air in the mills. Larger motors were installed on the fuel transport pumps than were originally contemplated but no difficulty has been experienced in transporting and distributing the powdered coal if it is dry enough. Pulverized fuel transport pipes are carried over the ground to the boiler plant on A-framed steel structures, on which are also carried steam main and water and air pipes, all enclosed in a circular insulated metal cover.

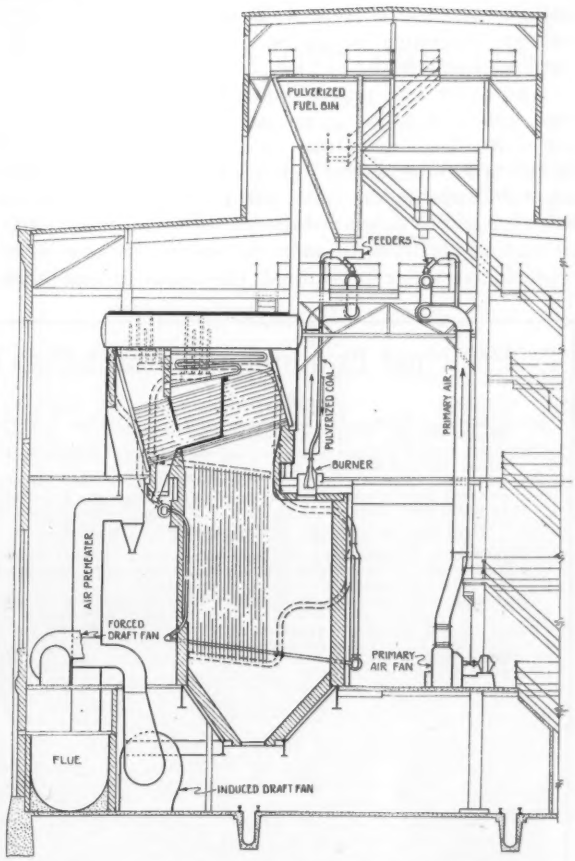


FIG. 3. PARTIAL SECTION THROUGH BOILER HOUSE SHOWING BOILER SETTING, FANS AND COAL BURNING EQUIPMENT

Design of Boilers and Furnaces

The present boiler plant is designed for eight (seven installed) 1016-hp. boilers with pulverized fuel furnaces and with individual air preheaters. Each boiler is provided with a separate, concrete, pulverized-coal storage bunker fed by duplicate fuel transport pipes. At the bottom of each bunker three duplex, d.c. motor-driven feeders are provided. The six feeder screws supply six vertical, forced-draft burners located in the horizontal flat arch directly in front of the boiler.

In designing the furnaces, the engineers had to provide a furnace for low grade Nova Scotia coal having a low fusing point ash, as well as for high grade Pennsylvania or West Virginia coals together with other available coals, all at average boiler ratings of 200 to 250 per cent with maximum rating of 300 per cent. For the Nova Scotia coal it was deemed necessary to provide a horizontal water screen and deep ash pit, also to make the distance between the top of the horizontal water screen and the underside of the arch sufficient so that at all times the flame could be kept above the water screen to prevent slagging the ash in the furnace hoppers. Partial sidewall fin screens and back wall fin screens were provided to reduce the furnace maintenance and reduce furnace temperature at the higher

ratings. Air-cooled front walls and part of each sidewall are refractory to insure ignition of the coal and complete combustion.

The boiler feed supply water is heated in an open tank heater, installed in the mill basement and receiving waste steam and drips from the mill. This water at 180 to 190 deg. is fed into duplicate open feed water heaters located in the boiler plant. It then flows down to either of two steam-turbine-driven boiler feed pumps or to a motor-driven pump. In case of emergency, or when hotter water is required, the steam driven pump from the same panel. The forced draft preheated air leading into the side of the furnace and also into the burners is controlled manually by hand-wheels extending to the front of the boiler close to the boiler instrument panels.

All the coal preparation plant equipment and all the boiler plant auxiliaries are electrically driven by 550-v., 62½-cycle current with the exception of d.c. feeder motors. Each motor drive is provided with a starter directly alongside and, in addition, with a circuit breaker in a central control room at the end of

Principal Equipment in Canadian International Paper Co. Boiler Plant

General

Location—Confluence St. Lawrence and St. Maurice Rivers, Three Rivers, P. Q., Canada.
Capacity, boiler horsepower—installed, 7112 in 7 units; ultimate, 8128 in 8 units.
Engineers—McClellan and Junkersfeld, Inc., under direct supervision of A. H. White, Chief Engineer, International Paper Co.

Boilers, Superheaters and Air Heaters

7 Babcock & Wilcox Co., straight tube, water-tube boilers; 10,160 sq. ft. heating surface each, 4-in. tubes, designed for 135 lb. pressure, 100 deg. superheat.
7 Babcock & Wilcox Co., convection type superheaters, 2800 sq. ft. surface per boiler to give 100 deg. superheat.
Water cooled walls, Combustion Engineering Corp., fin tube, 1201 sq. ft. per boiler and Lopulco water screen.
Furnace volume above water screen.....8200 cu. ft.
Furnace wall construction.....Combustion Engineering Corp., with curved front and shadow tile.
7 Combustion Engineering Corp. plate type air heaters, 6363 sq. ft. each. Preheater duct work..Vickers, Ltd., Canada

Fans and Draft Equipment

7 B. F. Sturtevant Co. induced draft fans, capacity 88,000 c.f.m. each at 425 deg., 2.5 in. pressure; driven by 550 v., 3-phase, 62½ cycle, 75-hp. 2-speed pole changing motor.
7 B. F. Sturtevant Co. forced draft fans, capacity 35,000 c.f.m. each at 100 deg., 3 in. press, driven by 550-v., 3-phase, 62½ cycle, 40-hp., 2 speed pole changing motor.
1 Heinicke Chimney Co., radial brick chimney, 200 ft. high, 10 ft. diameter. Hollow tile flue.

Coal and Ash Handling Equipment

2 Canadian Mead-Morrison Co., traveling electric coal towers, capacity 200 t. an hour each.
2 Canadian Mead-Morrison Co., drag scrapers, capacity 200 t. an hour each.
Conveyors, Canadian Mead-Morrison Co., two 36-in. conveyors each 400 t. an hr. maximum capacity. One 24-in. conveyor in prep. house, 100 t. an hour.
2 Canadian Mead-Morrison Co. single roll crushers, 100 t. an hr. each.
Ash hoppers and ash gates.....The Allen-Sherman-Hoff Co.

Pumps and Heaters

2 Cochrane Corp. open feed water heaters, capacity each 210,000 lb. an hour.
4 Ingersoll-Rand Co., A. S. Cameron type centrifugal boiler feed pumps, 450 ft. head, one 500-g.p.m. and one 800-g.p.m.; driven by 150-hp., 3-phase, 62½-cycle, 550-v. motors; one 500-g.p.m. and one 800-g.p.m. driven by single-stage Terry turbines.
Copes feed water regulators.....Northern Equipment Co.

Coal Preparation Plant

5 Combustion Engineering Corp. vertical gravity grid type dryers, 1190 sq. ft. each, 6 t. an hour.
5 Combustion Engineering Corp. Raymond 5-roller, air separation pulverizing mills, 6 to 8 t. an hour each.
2 Fuller Lehigh Co. Fuller-Kinyon coal transport pumps, 30 t. an hour each with Fairbanks scales.

Feeding and Burning Equipment

3 Combustion Engineering Corp., Lopulco duplex type feeders per boiler (6 feeder screws) driven by three 3-hp., 250 v.d.c. motors.
6 Combustion Engineering Corp. Lopulco vertical forced draft burners per boiler.
4 B. F. Sturtevant Co. primary air fans, 1 for 2 boilers, each 9000 c.f.m. at 100 deg., 20 in. pressure, driven by 100-hp. a.c. motors.

Accessories and Miscellaneous Equipment

Piping—Main steam, Crane Co.; boiler feed, A. M. Byers Co., genuine wrought iron.
Valves—Main high pressure, c.i. body, bronze mounted, 250 lb., Jenkins Bros.; boiler feed line valves, Jenkins Bros.; non-return valves, Golden-Anderson Valve Specialty Co.
Insulation .....Johns-Manville Corp.
Blowoff valves; water screen, Yarnall-Waring Co.; boiler, Galt.
Safety valves....Ashcroft (Manning, Maxwell & Moore, Inc.)
Steam gages.....The Ashton Valve Co.
Boiler meters and multi-pointer draft gages.....Bailey Meter Co.
Water columns.....Babcock & Wilcox Co.
Temperature recorders.....The Foxboro Co., Inc.
Boiler damper control..Designed by McClellan & Junkersfeld
Soot blowers.....Diamond Power Specialty Co.
Motors and electrical equipment.....General Electric Co.
M. & M. safety grating.....McGregor and McIntyre
Ingersoll-Rand Co. air compressors, each 100 c.f.m. at 100 lb. pressure.
Furnace arches .....
....Bigelow Arch Co. (4); Liptak Firebrick Arch Co. (3)

can be operated exhausting directly into the feed water heater. The boiler feed discharge system is provided with two headers; a main ring header is located directly over the boilers and connected to the boiler drums through feed water regulators; an auxiliary ring header is provided directly below the firing floor, which is connected to the boiler drums through accessible hand regulating valves. Pressure is carried on both feed water discharge headers at all times.

Convenient Arrangement Gives Ease of Control

One fireman operates four boilers. This ease of control is obtained by placing the four boiler control boards on the firing floor close to each other and having all the indicating, recording and control equipment mounted on these panels. Induced and forced draft fans are driven by two-speed pole-changing motors operated by push button control mounted on this panel. In order to obtain variations and boiler rating other than that provided by the two-speed fans, an electrically-operated damper is provided in the air preheater gas outlet; this damper is controlled by push button

both the preparation plant and the boiler plant. Power for driving all the boiler and preparation plant auxiliaries is ordinarily supplied by hydro-electric power over transmission lines to the mill; however, in case of power supply interruption, a 500-kw. synchronous turbo-generator is available. This unit floats on the line and, in case of voltage drop, automatically picks up the load of the essential auxiliaries in the boiler plant, thus insuring continuity of boiler operation and emergency lighting at all times.

A year's operating has demonstrated that Pennsylvania and Nova Scotia slack coals can be prepared and burned economically; furnace and boiler operation has shown high efficiency with complete combustion, a minimum of slag and practically no maintenance for this period. Present steam production fuel costs indicate a saving of forty per cent compared with the previous oil fired plant.

This plant was designed by McClellan and Junkersfeld, Inc., under the direct supervision of A. H. White, chief engineer of the International Paper Co.

Clearance Pockets for Ammonia Compressors

DESCRIPTION OF RECENT DEVELOPMENTS IN CLEARANCE POCKETS. AMOUNT OF CLEARANCE NECESSARY FOR ZERO CAPACITY. CONSTRUCTION AND OPERATION. BY W. H. MOTZ*

ONE OF THE RECENT developments in ice making and refrigerating machinery is use of clearance devices or pockets on ammonia compressors. The main purpose of such clearance pockets is to permit the operator to vary the capacity of the machine according to the demand for refrigeration. Due to the fact that many of the modern compressors are driven by constant speed motors, the problem of varying the capacity of the machine to suit the load presented itself.

This problem has been solved practically by fitting a special head on the head-end of the compressor cylinders. In these special heads are a number of clearance spaces or pockets. Usually, three such pockets are used on each cylinder head. Each pocket is connected to the inside of the cylinder by means of a special built-in stop valve, so that the capacity of the head-end of the cylinder may be reduced from full capacity to zero capacity in three steps.

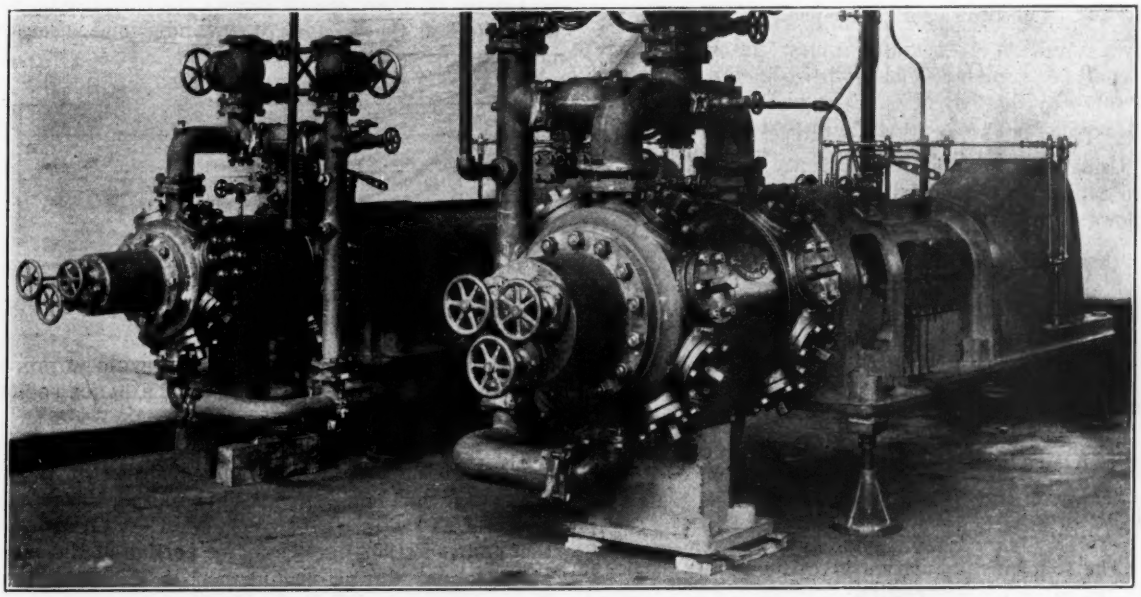


FIG. 1. THIS SHOWS THE APPEARANCE OF THE CLEARANCE POCKETS AND THE MANNER IN WHICH THEY ARE BOLTED TO THE CYLINDER

The general construction of the clearance heads for ammonia compressors is shown by Fig. 1, in the application of clearance heads to a two-stage compressor. The clearance heads are bolted to compressor frame just as a standard head. The cylindrical extension contains the three pockets and three special valves. The valve stems extend through the end of the head extension in stuffing boxes. Suitable hand wheels are provided for operating the valves.

By opening one of the valves, a certain amount of clearance space is connected to the head end of the cylinder. When the piston approaches the head-end, the gas is compressed into the clearance space; when the piston recedes, the gas in the clearance expands through the special valve into the cylinder again. The amount of clearance required for such pockets depends upon the relative size of the cylinder and a number of other conditions which are discussed in the following paragraphs.

*Technical Engineer, Hill Manufacturing Co., Chicago, Ill.

AMOUNT OF CLEARANCE NECESSARY

The amount of clearance to be introduced into the cylinder in order to obtain a given capacity reduction depends upon the relative suction and discharge pressures. In speaking of the amount of clearance, it is commonly expressed as a percentage of the stroke—volume of the cylinder. By means of the laws of gas compression, as given in most books pertaining to thermodynamics, it is possible to calculate the necessary clearances for various capacity reductions. The volumetric or displacement efficiency due to clearance is given by the following thermodynamic formula:

$$E_e = 1 + C - C\,(P_2 \div P_1)^{\frac{1}{n}} \quad \ldots\ldots\ldots\ldots \quad (1)$$

where

E_e = volumetric efficiency due to clearance.
C = percentage of clearance, expressed as a decimal fraction of stroke-volume.
p_2 = absolute discharge pressure.
p_1 = absolute suction pressure.
n = 1.28, for superheated ammonia vapor.

As an example in the use of the foregoing formula, it will be assumed that a compressor has a clearance of 5 per cent; that it operates at the standard pressures of 34.27 lb. abs. (5 deg. F.) and 168.2 lb. abs. (86 deg. F.) during the suction and discharge. The volumetric efficiency for this case may be found as follows:

$$E_c = 1 + C - C\,(P_2 \div P_1)^{\frac{1}{n}}$$

$$E_c = 1 + 0.05 - 0.05\,(169.2 \div 34.27)^{\frac{1}{1.28}}$$

$E_c = 0.876 = 87.6$ per cent.

The foregoing calculations show that a clearance of 5 per cent reduces the capacity 12.4 per cent for the standard pressures.

The amount of clearance to be used in order to reduce the capacity to zero may be determined also by the foregoing formula.

It is possible to derive a formula, from the above equation, which will express the clearance requirements for zero capacities. The equations are given as follows:

$$E_c = 1 + C - C\,(P_2 \div P_1)^{\frac{1}{n}}$$

Let $E_c = 0$

C_1 = clearance for zero capacity

$$0 = 1 + C_1 - C_1\,(P_2 \div P_1)^{\frac{1}{n}}$$

Therefore

$$C_1 = 1 \div [(P_2 \div P_1)^{\frac{1}{n}} - 1] \quad \ldots\ldots\ldots\ldots \quad (2)$$

Using this formula the clearance requirements for zero capacity at standard conditions may be found as follows:

$$C_1 = 1 \div [(169.2 \div 34.27)^{\frac{1}{1.28}} - 1]$$

$C_1 = 0.403 = 40.3$ per cent.

Consequently, a clearance of 40.3 will reduce the capacity to zero for standard pressures.

Formula 2 may be simplified in the following manner:

Let $K = (P_2 \div P_1)^{\frac{1}{n}}$

Then $C_1 = \dfrac{1}{K - 1}$

The following tabulation gives the values of K for various ratios of compression:

$P_2 \div P_1$	K
3	2.36
4	2.95
5	3.51
6	4.05
7	4.57
8	5.07
9	5.56
10	6.04
11	6.51
12	6.96
13	7.41
14	8.85
15	8.29

The effect of clearance may be shown graphically on the pressure-volume or indicator diagram. In Fig. 2, the diagram AEBF represents the relationship of pressures and volumes, when the compressor cylinder has no clearance. Line AE represents the compression of the gas. Line EB represents the expulsion of the gas from the cylinder. Line FA represents the suction stroke of the compressor. Theoretically, it will be observed that the capacity is equal to the displacement of the piston. Of course under practical conditions there are unavoidable losses which must be allowed for. It is further observed that the area of diagram AEBF determines the amount of work required for the compression and expulsion of the gas. Now if clearance is introduced into the cylinder by means of clearance pockets, it is possible to reduce the capacity to zero, as previously indicated. Referring to Fig. 2, line BC represents a clearance volume of 40.3 per cent. In other words, BC ÷ BD = 0.403. The compression of the gas under these conditions is represented by the compression curve AB. The volume of gas in the cylinder and clearance pockets at the beginning of compression is represented by line DC; the volume of gas in clearance after compression is represented by line BC. The piston travels the entire stroke before the pressure reaches 169 lb. at point B and the piston recedes to the end of the stroke before the pressure is reduced to 34 lb. at point A.

Curve AB therefore represents the compression and expansion of the gas in the cylinder and clearance pockets.

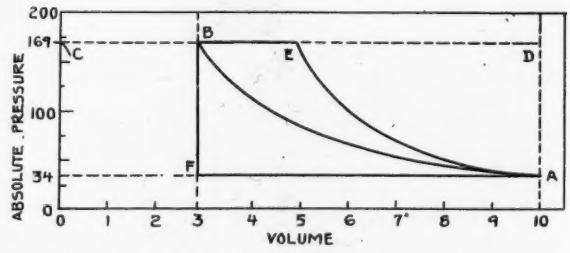


FIG. 2. PRESSURE-VOLUME DIAGRAM SHOWING ACTION OF THE COMPRESSOR WITH AND WITHOUT CLEARANCE POCKETS

As regards work requirements, it will be observed that, since the compression and expansion of the gas follows the curve AB, no work is required, theoretically speaking. Practically some energy is lost through friction and radiation, but the major portion of the energy given to gas during compression is recovered again, during the expansion of the gas.

Details of Construction and Operation

The details of construction of one type of clearance pocket head are shown by Fig. 3 which is a longitudinal and cross section of ammonia compressor cylinder equipped with such a head. This special head is arranged for bolting on the head of the cylinder as shown. It contains only two pockets or clearance spaces. The clearance spaces are connected to the cylinder by means of suitable ports. The opening of these are controlled by valves, the stems of which extend through stuffing boxes to suitable hand wheels on the outside. To cut in a section of the clearance space the hand wheels on the outside are turned in the proper direction to open the valve in the head. The clearance pockets are cut out of operation by closing the valves.

The type of clearance head shown in Fig. 3 makes it possible to reduce the capacity of the head of the cylinder to practically zero in two steps.

The essential advantage in the use of clearance pockets is that obtained by being able to vary the capacity of the compressor in some proportion to the refrigeration demand. As previously indicated, operators of ice and refrigerating plants running under vari-

able loads will appreciate this facility. When the refrigeration load declines, the operator is able to cut in the clearance pockets. The practical result of this operation is that the suction pressure is maintained at a higher average than would otherwise be possible with a constant displacement compressor. The economic benefit of maintaining a high suction pressure is appreciated when it is remembered that a reduction of one pound in the suction pressure decreases the refrigerating capacity over 3 per cent and increases the power consumption per unit of refrigeration about 2½ per cent. These percentages show why it is desirable to maintain the highest possible suction pressures, yet obtaining the desired temperatures at the points of application of the refrigeration.

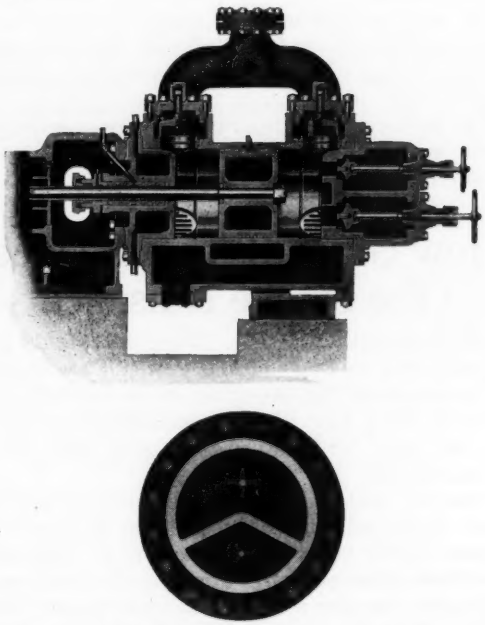


FIG. 3. SECTIONAL VIEW TO SHOW THE CONSTRUCTION OF THE CLEARANCE POCKETS. THIS TYPE OF CLEARANCE HEAD MAKES IT POSSIBLE TO REDUCE THE CAPACITY OF THE HEAD OF THE CYLINDER PRACTICALLY TO ZERO

Sometimes the following question has been asked regarding clearance pockets: Is it more desirable to install a number of small units without clearance pockets than to install a lesser number of larger units each equipped with clearance pockets?

In the first case, flexibility of operation is obtained by installing several small units, so that machines may be cut in or out of service according to the refrigeration demand. In this method of operation, each unit, while running, would develop its rated capacity, and thus operate at a good efficiency. On the other hand, however, consideration must be given to difference of efficiencies of smaller as compared to larger units. Generally, the operating or machine efficiency increases with the relative size of the compressor. Therefore, in the second case, in which larger compressors with clearance pockets are used, the gain in operating efficiency due to larger machine may offset the unavoidable losses of friction and wiredrawing of gas in being compressed into, and expanded out of the clearance pockets.

Other factors to be considered in the economic solution of the question are initial and operating costs of the two classes of machines. The final selection of a given class of machines for a particular plant would be in favor of the type of machine which produces refrigeration at the lowest manufacturing cost, due consideration being given to all the local conditions in the plant.

Quite a number of ammonia compressors are equipped with clearance pockets, at present, in various types of ice and refrigerating plants. The consensus of opinions of operators of such equipment indicates that the clearance pocket is an adjunct to the efficient operation of ammonia compressors.

Test Results on Preventing Burnouts in Electrical Machinery

A RECENT NUMBER of the Siemens Zeitschrift gives some interesting results obtained in testing electrical machinery for prevention of burnouts. Various insulating materials were tested in the machines in various gases and mixtures of gases. Engineer Fritz Liebscher of the experimental station in the dynamo works of the Siemens-Schuckert-Werke reports the following results in summary in the article, "Protection of Electrical Machinery Against Burnouts":

For protection of electrical machinery equipped with circulating cooling against burnouts, a very rapid decrease in oxygen in the cooling plant by the introduction of inert gases is recommended. This is best done by injection of liquid carbonic acid. Cutoff valves are used to cut the machine off from the balance of the cooling plant in case of necessity.

Tests have shown that the independent combustion of insulating material (cotton strips, excelsior strips, paper, shellac) is impossible when the gas contains only 14 to 15 per cent oxygen. In order to reduce the oxygen percentage from the 21 per cent to 14 per cent, that is one-third, one-third of the air chamber volume must be replaced by the injected gas. This requires a gas volume equal to one-half of the air chamber volume. More gas is required if the cooling plant leaks; less gas is required if the flow of the oxygen-poor gas is increased.

From 90 to 120 grams of insulating material burned in one cubic meter of air. The use of carbonic acid as a fire extinguisher has, as compared to nitrogen gas, the advantages of more rapid expansion in the machine, less demand on the compressed flasks in storage, less cost and easier availability. The full enclosure of electrical machinery and cooling in view of the above results will insure against burnouts due to short circuits.

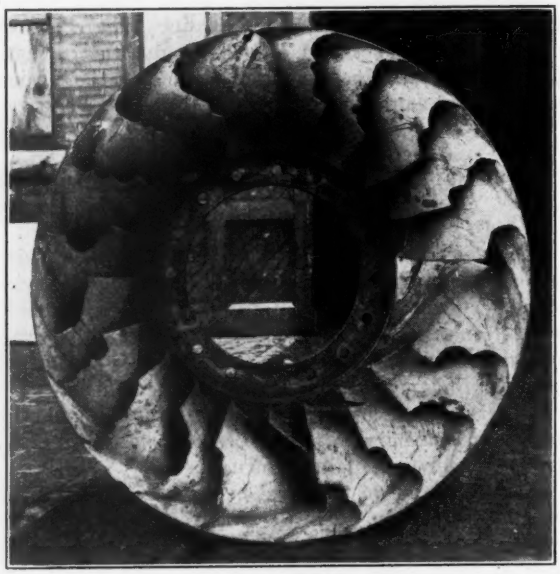
Developments in High-Speed Oil Engines

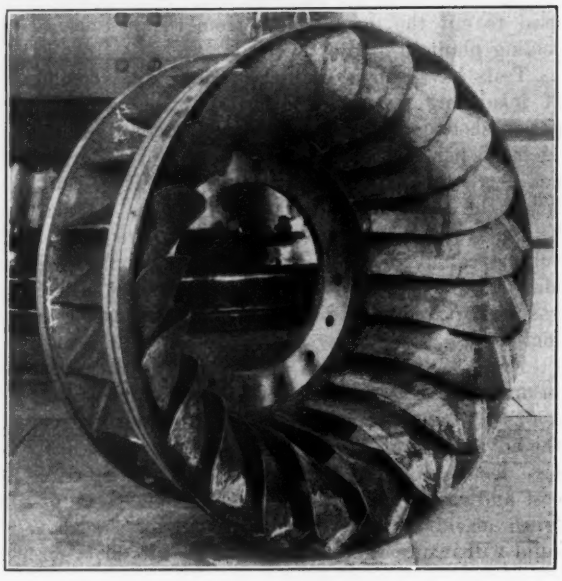
IN THE ARTICLE under the above title appearing on p. 409 of the April 1, 1927, issue, credit was inadvertently omitted. This article was read as a paper before the Metropolitan Section of the A. S. M. E. on Feb. 25.

THE MAN who gets along is the man who pulls more than his own weight.

Worn Turbine Runner Repaired by Welding

AN EXTREMELY interesting case of electric welding repair came to our attention recently during a visit to the Niagara Falls Power Co. This consisted in the repair of a turbine runner which had been badly





THE WORN RUNNER IS SHOWN AT THE TOP. UNDER THE SKILLFUL HANDS OF THE WELDER, THE RUNNER SPROUTED NEW BUCKETS AS SHOWN BELOW, MAKING IT AS GOOD AS NEW

corroded during eight years of constant service. The worn runner is shown at the top in the accompanying photograph. Not only are the bucket surfaces badly pitted but the edges and in some cases the entire buckets were worn away.

Before a method was developed whereby repair could be effected by electric welding such runners, costing as much as $5000 were a total loss. Now under the skillful hands of Rudolph Long of the Niagara Falls Power Co., they are repaired at a cost of about $500 and made as good as new. This applies not only to runners which have been worn by long service but also to wheels which have been broken by trash and ice jamming.

Heretofore the difficulty lay in the fact that bronze could not be welded by the electric arc process. Mr. Long, however, by constantly experimenting developed a method whereby bronze can be welded by the arc process with the same facility as iron. He discovered that bronze must always be welded from the positive side and that all air movement or drafts must be guarded against. The welding current normally used in this work has a value of 350 amperes at 60 volts.

One turbine runner for a 10,000-hp. machine repaired by this method seven years ago is still in service at Niagara Falls.

The photographs of the runners were supplied to us by courtesy of "Power Events" of the Buffalo, Niagara & Eastern Power Corporation.

How Great Britain Reduces the Smoke Nuisance

THE ENGINEER of Feb. 25 reports that 29 public authorities in England and Scotland are co-operating in measuring the impurities in the air within their districts. They have 61 gages installed, of which London has nine, for measuring the soot and dust fall during the year.

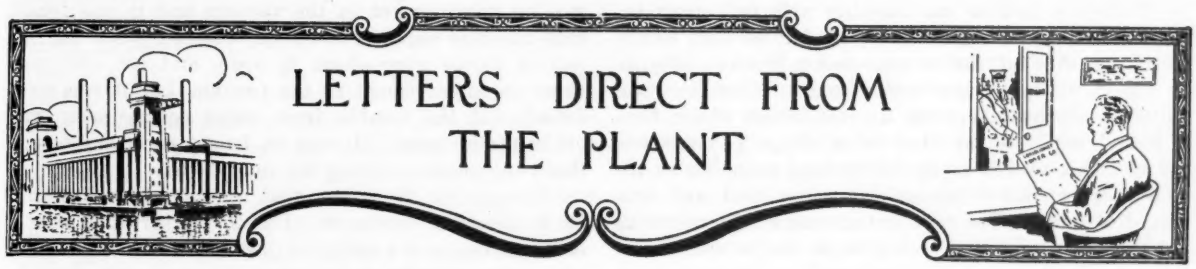
Soot and dust which fell in London amounted to 298 t. per square mile in 1924-5 and 255 in 1925-6. The average for the years 1918-22 was 355 t. This shows a remarkable improvement in atmospheric cleanliness.

Glasgow also uses nine dust and soot gages. The impurities from the air amounted to 285 t. per square mile in 1924-5, 275 in 1925-6, and an average of 328 for the years 1918-1922.

Towns and cities with an area of more than one square mile need more than one gage. Interesting comparisons on the precipitate in various towns are made. The towns are listed in several classes. As they become more efficient in meeting the smoke and soot abatement problem, they are placed in a higher class. Considerable rivalry is thus developed. The results have been eminently satisfactory.

IN MANY classes of industry, the bearings of heavy machines come in contact with water or other liquids. Oils which will readily emulsify with water are not suitable for this service, as the presence of water is generally detrimental to good lubrication and should be guarded against, in order to prevent sludge and other deposits from forming.

Where water cannot be kept out of the bearings, it is permissible to pack the bearing with hard grease in addition to the regular lubrication. Then, in case the oil supply becomes stopped or inefficient, the grease will melt as the bearing heats and act as a stop gap until the bearing can be given the proper attention.



Water Backing Up Into Engine

ON PAGE 159 of the January 15 issue the question is asked, "What causes water to back up into a steam engine which is connected to a barometric condenser set 34 ft. above the hotwell?"

Although I have never had any experience in getting water back into a reciprocating steam engine connected to a barometric condenser, I have had some experience in getting water back into a steam turbine while running connected to a barometric condenser. I do not think it is possible to get water back with all types of barometric condensers, but with certain types I am sure it is possible under certain conditions.

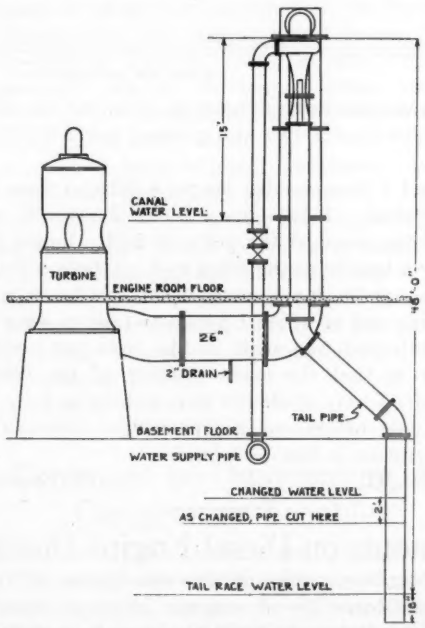


FIG. 1. LAYOUT SHOWING RELATIVE POSITIONS OF TURBINES, CONDENSER AND WATER LEVELS

In the plant to which I refer, we had one Corliss cross compound condensing engine, three other reciprocating engines of different makes and a 75-hp. water wheel. It was decided to discard the engines and water wheel and install two vertical Curtis steam turbines of 750 kw. each. The water for the wheel and condenser was supplied through a penstock leading from a canal above the engine room. The injection water for the barometric condensers was supplied through a 14-in. pipe connected to the penstock.

Turbine No. 1 was installed in one of the engine rooms alongside of the engine which the writer chanced to be operating at that time. To save the expense of putting in a special hotwell, it was decided to run the tail pipes of the condenser down into the raceway from the water wheel. This gave a height of about 48 ft. from the level of the water in the raceway to the condenser head, as shown in Fig. 1. The distance between the level of the water in the canal and the condenser head was 15 ft. A 2-in. drain pipe was connected to the bottom of the exhaust pipe for the purpose of draining out all condensation when the turbine was not in use and was also used as a vacuum breaker when shutting down.

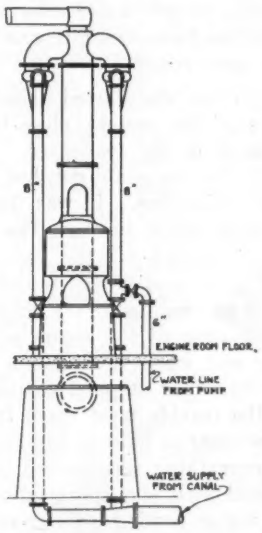


FIG. 2. MANNER IN WHICH THE TWIN CONDENSERS WERE CONNECTED

Twin condensers were used in this installation and a 6-in. water line, leading from a steam driven pump was connected to one of the 8-in. injection lines, as shown in Fig. 2.

When starting up, the valves on the injection lines were closed and the one on the pump line opened and water forced over till the vacuum was picked up. Then the injection valves were opened and the pump shut down and the water would syphon over from the canal line.

When the time for starting up the installation arrived, the erecting engineer gave the word to turn on the steam and try out the turbine for speed, balance, etc. The vacuum was picked up, the oil pumps started, the steam turned on and the turbine brought up to speed. It was found that some minor adjustments were needed and the writer was instructed to go below and open the 2-in. drain valve to break the vacuum.

While the turbine was running with full steam on, the vacuum had been about 26 in. but as soon as the steam was shut off, the vacuum took a jump to 29½ in. as was shown by the mercury column. When the drain valve was opened there was a great inrush of air, then a loud bump like the blow of a sledge hammer was heard. This proved to be the turbine dropping to the step bearing, but it immediately rose clear and continued to rotate. The next instant water began pouring out the drain pipe and soon it came out as cold as the ice water in the canal.

This was immediately reported to the erecting engineer, who started an investigation. At the condenser, water could be heard running down the inside of the exhaust pipe and the pipe was nearly ice cold. The valve on the injection line was closed and soon the water ceased coming out the drain pipe. This was a condition which had not been anticipated and, as it did not seem possible to get water over with the hotwell 48 ft. below the condenser head, it was tried out several times with the same results.

When the turbine was started under full load, after the installation of the motors, close tab was kept on everything, especially the condenser. About 26 in. of vacuum was the best we could get, but everything went along fine until noontime. It was decided to let the turbine just drift along through the noon hour, but when the load dropped off the vacuum immediately went up to 29½ in. and it was found that water was coming over. It was decided to try reducing the vacuum by shutting off some of the steam on the seal rings. This was done and when the vacuum had dropped to about 26 in. the water stopped coming over. It was thought that the trouble must come from the installation of the condenser or hotwell but when No. 2 turbine was installed everything was carried out in accordance with the original plan and specifications but the same trouble with water coming over was experienced as with No. 1 unit.

This raceway consisted of a brick archway extending underneath the mill and emptying into a brook. It became necessary to do some excavating in the brook, which lowered the water in the raceway, necessitating the building of a dam across the raceway to provide a hotwell. As it was thought that the extreme length of the tail pipe might have something to do with the water coming over, it was decided to build the dam high enough to allow eight feet to be cut off the tail pipe as shown in Fig. 1. The changes, however, had no effect on the water coming over, but whereas it was possible to get 27½ in. of vacuum when running at test, as in the former case, only 26 in. could be obtained in the latter case.

When first installed the injection water for both condensers was taken from a single 14-ft. main as shown in Fig. 1, reducted down at the No. 2 condenser as shown in Fig. 2, but as 26 in. of vacuum was not satisfactory, it was thought that the water supply was not sufficient so an independent water line was laid to supply the No. 2 condenser. This, however, did not improve the vacuum. It was then thought that possibly the water supply might be too great, so the operating engineer tried cutting down the supply by closing down on the valves on the supply lines and immediately there was an improvement in the vacuum and it was found that the best vacuum could be obtained when the injection valves were about ¾ open, and not only was there an improvement in the vacuum, but it was soon found that the trouble from water coming over was entirely eliminated. It was no longer necessary to cut down the vacuum during the noon hour.

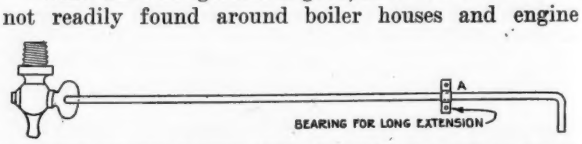
It appeared, therefore, that the trouble was caused by flooding the condenser. Due to the throat or nozzle construction in the tail pipe just below the fixed cone, where the injection water enters the condenser, there is a restricted area which was not sufficiently large to take care of the sudden increase in the vacuum in the exhaust pipe.

Lowell, Mass. E. C. WELLS.

Extension for Inaccessible Drain Cocks

FRANK W. BENTLEY, JR., illustrated in the issue of Feb. 1, 1927 a convenient extension for pet cocks placed in inaccessible places.

While his arrangement is good, automobile valves are not readily found around boiler houses and engine



AN ORDINARY ROD PASSED THROUGH HOLE DRILLED IN DRAIN COCK MAKES CONVENIENT AND QUICKLY APPLIED EXTENSION

rooms and I have needed longer extension than Henry Ford's valves. I have used ¼-in. brass rod, with a short 90-deg. bend at the pet cock and a longer 90-deg. bend for a handle at the other end. A hole is drilled in the cock handle for a snug fit of the brass rod, the protruding end of which I hammered flat to keep it put. The handle end was made in line with the position of the cock so that the exact position of the valve was indicated. I have made the rods as long as 3 ft.

For long extensions, a pipe hanger shown at A in the illustration is used as a guide.

Dayton, O. C. W. STEVENS.

Comments on Diesel Engine Operation

IN FOLLOWING through the description of the new Fairbanks-Morse Diesel engines in your mid-October issue, one of the statements appeared to differ from ordinary Diesel engine operations and I should like to have the opinion of other Diesel operators upon the point.

One sentence, on page 1107, distinctly says: "Starting air is used on all cylinders during this period and the fuel pumps arranged to inject a full charge of fuel into the combination chamber." Usually engines are constructed so that during the period of starting air pressure is on the cylinders, the fuel pump or fuel valve as the case may be is made imperative.

In the early days, and even in some modern engines, the starting mechanism and fuel pumps were not interlocked mechanically and the operator had to operate both at once. Injecting fuel with the starting air is dangerous and can cause serious damage, although usually, if the starting is done quickly, the only result will be a heavy knock and irregular running for a short

period, similar to the action when a fuel valve is stuck open.

If I understand the operation of the new engine correctly, both air and fuel are injected into all cylinders with the air cut off; first, three and then, all six of the cylinders, as firing begins. During the period that both are being admitted, the cooling effect of the starting air is relied upon to keep the fuel from burning. Even with quick starting, with the starting wheel swung from position to position, there is bound to be some irregularity in the firing with dangerous acceleration of the moving parts.

Fuel is injected into the upper combustion chamber and starting air in the lower part. Compression takes place as usual on the upstroke and some of the lighter hydrocarbons in the oil will burn while the heavier parts will collect in the chamber and ignite after the starting air is cut off. These two or three charges of oil are bound to cause violent explosions, irregular running and excessive acceleration as the fuel pump or governor has no control.

In the marine reversing engine the importance of this point is recognized by provision to disengage the fuel pump while the starting wheel moves from stop to first starting position. Fuel injected into the hot cylinder before the engine stopped would cause serious complications and it seems equally important to protect the engine under other conditions as well. Ordinarily, when starting under good conditions, there is little cause for worry; but if, through an error, the engine was operated for some time at the first or second starting position, the engine would undoubtedly wreck itself.

No more interesting and important topic for discussion has come up for some time and the opinion of other Diesel engine men and operators who have had experience along this line will, undoubtedly, bring out many interesting details.

Los Angeles, Cal. G. REED.

Comment on Overcoming Air Compressor Troubles

REFERRING to Mr. Jensen's article, page 477 of the April 15 issue, I believe that the report should have been more complete. In the case of both steam and air, mention was made only of the high pressure side. When repairs are made to one side, the other side should be inspected to see if similar repairs are not needed there also, so that if for example both cylinders needed reboring, they should be rebored at the same time.

From the figures given, it appears that the cylinder mentioned was worn out of round about 0.012 in. In reboring the cylinder, however, it is necessary to take a much bigger cut than that required to overcome this irregularity because the boring tool would ride on the smooth hard surface if the depth of the cut were too small. It would be necessary, therefore, to increase the diameter at least ⅛ in. in a roughing cut and then follow this by a fine finishing cut.

In all cases 0.001 in. or 0.002 in. larger bore than was estimated would not make an appreciable difference in the operation of the machine. There should be sufficient clearance to allow for the expansion of the piston due to heat. In any case it is necessary to provide a piston, together with piston rings, which is ample in diameter and then bore the cylinder to fit this piston allowing sufficient clearance.

Besides inspecting the bore of the cylinders, the threads on the old rod and in the crosshead should be examined to see how much larger the thread on the new rod should be as the old rod, having been worn loose, as indicated in Jensen's article, had doubtless injured the thread in the crosshead. This latter should therefore be trued up if necessary.

Babcock segment step joint rings are commonly used on air compressor and steam engine pistons. Because of the springs at the back of the segments, they are kept against the wall of the cylinder with a more uniform pressure even though the cylinder may become considerably worn, than is the case with snap rings.

No mention is made, in Jensen's report, of the kind and condition of the rod packings. If the rods were packed with metallic packing, new packing would have to be provided to fit the new rod.

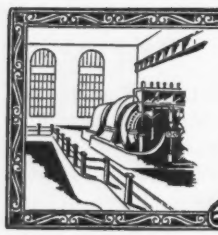
Worn shoulders on the flat surfaces of the steam chests could be scraped down to give the slide valves a better fit. Often the valves need scraping also. In this case they are tested on a known flat surface. If piston valves were used, the steam chest may require reboring and fitting with new piston valves and rings.

No mention is made of the air discharge valves or what should be done with them. If they are of the poppet type, they should be cleaned, examined and refitted to their seats. Grinding by hand is frequently sufficient to produce a good valve seat. Proper seating is important because a slight wire-drawing of the air through leaky valves causes excessive heating. Valve springs often become weakened through long service and provide another possible source for leakage and heating. Leaking of discharge valves and sticking while open is quickly indicated not only by the heating effect but also by the fact that the pressure from the tank is forced back through such valves and through the rotating suction valves, when they are open, to the intercooler. The safety valve on the intercooler popping to relieve the excess pressure indicates clearly that leakage has taken place.

Cambridge, Mass. R. A. CULTRA.

Editor's Note: If, as in the foregoing case, the amount of metal to be removed in order to "true up" the cylinder is small, it may be ground in place by rigging up a grinding device within the bore of the cylinder. In this case, it is true, that the parts at which the greater amount of metal is removed would be somewhat softer than those parts at which only a very small amount of metal is removed by grinding. But as indicated by the fact of original wear, these harder parts will also resist future wear better, hence the tendency toward retaining a true shape is even more probable than when the cylinder has all of its hard surface removed by boring.

MACHINERY EXPORTS made substantial gains in 1926. Oil-well machinery rose 49 per cent in value; construction and conveying machinery 33 per cent; electric motors 21 per cent; batteries 40 per cent; internal-combustion engines 37 per cent according to figures of the United States Chamber of Commerce.



QUESTIONS AND ANSWERS

Cold Storage Piping

WHAT IS the rule used in figuring the number of square feet required in the ammonia coils for a given temperature in a good insulated cold storage room?

E. G.

A. For direct expansion the lineal feet of one-inch pipe required per cubic foot of cold storage space are given in the accompanying table.

In the case of brine circulation, 1½ to 2 times the amount of pipe as given would be required.

If larger sizes of pipe are used, the amount required would be inversely as the diameter, i. e., if 2-in. pipe is used, one-half the amount given for the same conditions for 1-in. pipe, would be required.

By "excellent insulation" as given in the table is meant walls, ceilings, etc., through which the heat leakage does not exceed 2 B.t.u. for each deg. F. difference in temperature per square foot in 24 hr.; by "poor insulation" is meant a leakage under similar circumstances which amounts to 4 B.t.u. and more.

LINEAL FEET OF ONE-INCH PIPE REQUIRED PER CU. FT. OF COLD STORAGE SPACE

Approximate size of building in Cu. ft.	Insulation	Temperature °F.					
		0°	10°	20°	30°	40°	50°
100	excellent	3.0	0.78	0.48	0.36	0.24	0.15
	poor	6.0	1.50	0.90	0.66	0.48	0.30
1,000	excellent	1.0	0.26	0.16	0.12	0.08	0.05
	poor	2.0	0.50	0.30	0.22	0.16	0.10
10,000	excellent	0.61	0.16	0.10	0.075	0.055	0.035
	poor	1.2	0.33	0.20	0.15	0.11	0.07
30,000	excellent	0.5	0.13	0.08	0.06	0.040	0.025
	poor	1.	0.25	0.15	0.11	0.03	0.05
100,000	excellent	0.38	0.10	0.06	0.045	0.03	0.009
	poor	0.75	0.20	0.12	0.09	0.06	0.018

Heating Feed Water with Exhaust

WILL YOU PLEASE check this and give me your idea of the plan proposed?

Steam Data: We have a 6½ by 7-in. engine running at 200 r.p.m., steam pressure 130 lb., operating time per charge 68 min., charges run per day average 4.4.

Water Data: Water required per charge, 55 cu. ft. at 120 deg. F., average make-up water temperature, 40 deg. F.

Will the exhaust steam from the above engine heat the water as required? Also, please figure for me the saving obtained by using exhaust steam to heat the water over that obtained by using live steam at 130 lb. pressure and costing 0.43097 per 1000 lb. H. L. R.

A. Your idea is good, although, in this particular case, we are rather of the opinion that the amount of steam involved is so small that it would not pay you to go to any considerable expense to carry out the plan you suggest.

To raise 55 cu. ft. of water, that is, about 3500 lb. from 40 deg. to 120 deg. would require approximately 280,000 B.t.u.; 130 lb. of steam would supply about 1080 B.t.u. per lb. for heating the water, while the exhaust steam would have available a little less than this or approximately 1000 B.t.u. per lb.

We might say roughly that to heat the 55 cu. ft. of water you require for the charge would necessitate the use of about 280 lb. of steam per charge, or with 4.4 charges per day, this would be approximately 1250 lb. of steam, costing about $0.53. If you do not now make use of the exhaust from the engine and the piping changes necessary to utilize this exhaust steam in the heater are small, it is certainly the thing to do.

There will be an abundance of exhaust steam from the engine and the saving will amount to a little over $0.50 per day when steam costs $0.43 per 1000 lb. In case you are using treated water, there will also be a slight saving due to the reduction in the amount of raw water used, because the 1250 lb. per day would be reclaimed instead of going into the atmosphere.

Setting Corliss Valves

HOW ARE THE VALVES on a Corliss engine set?

L. D. J.

A. Although directions for valve setting are numerous, the following have some methods not commonly given and which are worth remembering. First, remove the steam and exhaust bonnets and upon the end of each valve will be found a mark corresponding to the opening edge of the port. The direction of motion for opening the valve can be determined by working the wristplate by hand.

Second, examine the wristplate hub and bracket. Upon the bracket will be found a mark corresponding to the central position of the wristplate and two others locating the extreme travel of the wristplate in either direction of motion.

Third, see that the rocker arm travels an equal distance each side of the vertical position. To do this, loosen the eccentric and rotate it slowly about the shaft. Then with a plumb bob and scale measure the distance the rocker arm travels each side of its central position, adjust the length of the eccentric rod to bring the distances equal.

Fourth, rotate eccentric about the shaft and see if the wristplate travels equal distance each side of its central position, as shown by the travel marks. If it does not, adjust the length of the hook rod to bring them equal.

Fifth, block the wristplate in its central position, then pull up the dashpot rods until the hook pins engage with the steam hooks. Adjust the length of the steam and exhaust radius rods until the valves have the proper amount of lap as determined by the size and speed of engine.

Sixth, throw the wristplate with the starting bar first to one, then to the other extreme position, and adjust carefully the length of the dashpot rods so that the steam hooks will latch with the hook pins when the wristplate is at its extreme travel, allowing 1/32 in. for clearance.

Seventh, place the engine on dead center and see that the hook rod is fastened to the wristplate. The eccentric should then be turned in the direction the engine is to run until the proper amount of lead is secured, fasten the eccentric to the shaft. Place the engine in the opposite dead center and measure the lead. If it is not the same, make it the same by adjusting the length of the steam radius rods.

Eighth, block the governor up half way in the slot and fasten the reach rod levers at right angles to a line drawn half way between the two rods. Adjust the length of the reach rods until the knockoff arm stands vertical; with the governor in this position, turn the engine over until the cutoff occurs, and measure carefully the distance the crosshead has traveled; place the engine so that it will be the same on the other side, and adjust the length of the reach rod until the cutoff will just occur. This insures equal cutoff at each end of the cylinder for these positions. See that the governor gag pot is properly adjusted, and that the pot is filled with light oil.

Ninth, drop the governor to its lowest position and see that safety blocks on the knockoff cams are adjusted so as to prevent the steam hooks from latching with the hook pins.

Tenth, tram your engine with a fine prick punch so as to be able to adjust it quickly in case of accident or in case it has been tampered with.

Unit Heat Value Computation

USING PROFESSOR Parr's formula for unit heat value,

$$\frac{\text{B.t.u.} - 5000\ S}{1.00\ (1.08A + \frac{22}{40}\ S)}$$

I have been trying to compute the heat value of the fuel burned in our plant but somehow I either do not understand the formula or my method is wrong. I seem to get results that are ridiculously low. We are burning Harrisburg coal analyzing as follows:

B.t.u.	12,390
Sulphur per cent	1.49
Ash per cent	12.73
Moisture per cent	2.92

Will you not kindly compute the unit heat value?

R. A. F.

A. In the preceding equation the B.t.u. is the indicated B.t.u. per pound. S and A represent the fraction of sulphur and of ash respectively.

Substituting your values in the above equation, we shall have:

$$\text{Unit heat value} = \frac{12{,}390 - 5000 \times 0.0149}{1 - (1.08 \times 0.1273 + \frac{22}{40} \times 0.0149)}$$

$$= \frac{12{,}315.5}{0.978} = 12{,}600$$

Strength of Boiler Sections

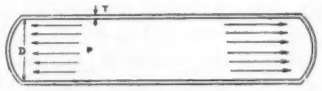
WHY IS the strain greater on the longitudinal joint than on the circumferential joint of a boiler shell?

N. A. B.

A. Assuming D = the diameter of boiler in inches, P = the pressure in pounds per sq. in., t = the thickness of plate in inches, S = the stress in the material in pounds per sq. in.; then for a longitudinal section, the total pressure on a unit length, say 1 in., equals P × D × 1, as shown in illustration. This pressure is resisted by two sections of plate, t inches in thickness, by 1 in. long. Then the pull in the material, 2t × S = P × D × 1, the total pressure exerted on it. Dividing both sides of the equation by 2t gives:

$$S = P \times D \div 2t \quad (1)$$

Considering a circumferential section, the total pressure on the end, pressure per square inch times area, is



STRESS ON CIRCUMFERENTIAL SECTIONS OF A BOILER

$P \times 3.14 \times D^2 \div 4$. This is resisted by a section of plate, t in. in thickness by a length equal to the circumference, 3.14 × D in. long = 3.14 × D × t sq. in. Then the resistance in the material, $S \times 3.14 \times t \times D = P \times 3.14 \times D^2 \div 4$. Dividing both sides of the equation by 3.14 × t × D gives:

$$S = p \times D \div 4t \quad (2)$$

Since the value of S obtained for a girth section (1) is one-half that for a longitudinal section (2), the strain on a longitudinal joint is twice that on a circumferential joint.

Distilled Water Causes Pitting; Superheater Mishaps

ANSWERS to the following questions would be appreciated:

1. Why is distilled water, such as returns from a heating system, not desirable for exclusive use as boiler feed water?

2. What mishaps occur most frequently to superheaters, such as used in connection with water-tube boilers? How are repairs made? R. R.

A. Distilled water when used exclusively as the boiler feed often causes pitting. The water becomes more and more acid in reaction and frequently it is necessary to add lime in some form to neutralize this acidity. It is for this reason that city water, which usually contains some calcium carbonate, is often added to returns from heating systems.

2. The principal mishaps that may occur to superheaters are "burning out" and "scale formation," the latter occurring when the superheater is not properly installed as when wet steam is allowed to enter the superheater coils. The only way to make repairs under these circumstances is to remove the tubes and install new ones. The smallness of the tubes and the fact that they are usually curved prevent cleaning after the manner of cleaning boiler tubes.

EDITORIAL COMMENT

1 Example=10 Sermons

For a long time the various power plant magazines have been telling the industrial power engineer what he ought to do and what he can do to improve the conditions in his plant. Recently several business magazines have shown interest in the subject from the standpoint of the industrial manager. Consulting engineers have added their voices to the chorus. The burden of this chorus has been that, if the industrial power plant engineer will only use to better advantage the materials already at hand, he can often effect tremendous improvements without the necessity of purchasing large amounts of new equipment. The value of example, however, is much greater than the value of preaching and in this issue we present an article that illustrates this point perfectly.

At the plant of the Pabst Corp., in Milwaukee, the passage of the 18th Amendment to the Constitution destroyed almost instantly the market for the product to which all the energies and equipment of this great organization had been devoted for many years. The problem was to save as much out of the wreckage as possible. This was done by transforming the entire plant into a central manufacturing district, in which smaller outside companies might lease building space and in which they would be supplied with power, heat and refrigeration from the power plant of the Pabst Corp.

In the account of how this was done, one of the important points brought out was the absolute necessity for securing an accurate picture of the existing conditions. For the first year or two after the new arrangement was made there was absolutely no way of determining the course of the enterprise because there was no way of obtaining records for the various departments. As soon as complete equipment of meters and instruments was installed, however, the picture was obtained.

It is to be noted that, with several minor exceptions, the only equipment purchased consisted of instruments. The picture they drew presented at first many unsatisfactory phases but these were attacked one at a time and, as they were gradually eliminated, a surprising improvement took place. This improvement is due primarily to the common sense methods employed in correcting the troubles that were revealed by proper use of instruments. As the reader will note from examining the article, the engines and boilers in the power plant are not of the most modern type and practically no changes have been made in them during the last four or five years. In short, the accomplishments show that, in this case at least, it was the men behind the guns that counted.

This article, showing what *has* been done, is equivalent to at least 10 sermons on what *ought* to be done in the industrial power plant.

Superpower and the Flood

Again the lower Mississippi Valley has been so flooded that destruction of property and personal hardships placed upon the inhabitants of the valley have exceeded all previous records. Power plants along the swollen rivers have suffered damages just as have all other industries but, fortunately, in many towns and cities, the plants are tied in to a system with other plants which are more fortunately located. Thus service has been maintained in many towns where the local generating plant is under water.

This same advantage of interconnection was demonstrated last year at the time Florida was swept by storms. Such circumstances as these test the effectiveness of the interconnected system in averting a complete shut down. Fire, wind or flood may completely destroy or incapacitate a power plant but, if adequate interconnection with other plants has been provided, the interruption of service to customers is usually of short duration.

This is superpower coming into spectacular service. Little is known by the user of electric power of the service rendered him daily by plants outside his immediate territory. It is only when he knows that the plant in his vicinity is shut down that he realizes his power needs are being served by a plant 25, 50 or 100 mi. away.

Interconnection has been going on rapidly for the past decade and such unfortunate circumstances as the floods in the Mississippi will stimulate further activity along this line.

Off Duty

Every once in a while even an engineer has an attack of intro and extrospection. It is good for the soul and mind of any man to have a look at himself once in a while and to estimate his own qualities, progress and probable future. That's a good job for an off-duty hour, so long as it isn't done to the extent that a man gets to thinking more of himself than of what use he can be to others.

In the April N. E. L. A. Bulletin, quite a number of prominent engineers, probably at the instigation of a wily editor, came out in the open with their ideas as to engineers as a job lot and as individuals—where they were lacking and why—where they are and should be going. Because these views are so human and sensible and reflect the thinking of engineers who have made good, we pass a composite picture, with liberal quotations along for your off-duty enjoyment. If you can get opportunity, reading the Bulletin as a whole will well repay for the time spent.

Alex Bailey, whom everybody knows to love, starts off with a typically Alex Bailey viewpoint, "The Engineer Atop His Tower." He does a bit of poetry from Gray's elegy about the owl and the "ivy-mantled tower"

and some editor, going Alex one better, works in a heading, "The Engineer Atop His *Ivory* Tower." And Alex didn't deserve it. Bailey claims that, if the engineer who is complaining that he is not getting the recognition due the importance of his work would pause once in a while to analyze his own case, he would get a wonderful enlightenment. And how! Because most of his work deals with hard, cold facts and too close devotion may rob him of appreciation of the so-called finer things of life. That owl got immortalized by Gray because he happened to hoot just at the opportune time to catch attention, though Gray didn't give a hoot for the owl except as a part of the picture. What did the owl want? Why hoot? Well, what do engineers want? Fame, power, wealth are not ordinarily rewards of engineering. Fame is easy. Hundreds have it because of wickedness or scandal. What engineer wants that?

Horatius—every boy knows about that bridge and Horatius' strut to fame. But who engineered the bridge for him to strut on? What engineer built the pyramids? But look at the pure reading space King Tut got—3000 yr. too late to be any good to him—because he was a well preserved young man.

And so Alex goes on to show that the engineer, as an individual is not in line to win fame or power or wealth, at any rate money wealth. His profession is one of service and *it* may be famous, powerful and create great money values. Then Bailey philosophy steps in and defines wealth that is worth having as "living a full life, fulfillment of ambition, happiness, health," and the engineer can acquire all these, if he will analyze himself as carefully as he does the daily problems of engineering.

Now as that Alex has had his say, comes Alex Dow, speaking as an engineer to executives, to tell why executives have trouble with engineers. He has been and is both and claims that he has, as an executive, repressed and stored up a choice collection of epithets when dealing with engineers whose technical solutions of problems took no thought of customers or finance. This Alex opines that picking a cub from a technical college because he has shown ability in the mazes of higher mathematics and planting him inside an engineering fence where no non-technically educated intelligences may intrude is not the way to develop wide usefulness. Some cubs can't be developed into complete engineers but, even if they gravitate back to slide rules and equations, putting technical graduates through all or nearly all departments will give them some appreciation of the multi-faceted structure into which their engineering has to fit.

Those who have executive ability—largely technical ability and horse sense in proper proportions—will become well-rounded engineers. They'll probably become executives and keep right on swearing or weeping because of the lack of engineers of proper caliber.

Then an executive too modest to sign his name comes along with his view of the engineer and pleads for engineers to talk understandable English about technical problems—showing economics, definite estimates, explanation of plants and processes and what will be accomplished—in language that a business man can understand. His plea is for economy, efficiency and reliability, adaptation of plant to surroundings and conditions, to ability and convenience of operators and reasonableness as to first costs. He agrees that this means training the engineer in other than engineering needs of a system and that this broadening training should be conceded so that engineering study, tempered with common sense may eliminate cost and grief. The hazard of overdoing preliminary engineering is slight.

"Where Do We Go from Here?" is the text on which C. F. Hirshfeld argues that in addition to applying the laws of science and of materials to design and construction of machines and structures, the engineer should always have a "keen appreciation of future possibilities." He ought to stand at least half on one foot in the future. He ought deliberately to determine where his power system must go from here to keep pace with future needs of various kinds of service. And he must plan to meet future changes in voltages, steam pressures, binary vapor systems and such like without too great cost for reconstruction.

It takes an active imagination to foresee what developments may reasonably—or even unreasonably—be expected, for changes come faster than anyone would dare prophesy. Pegging attention on right-now needs is likely to result in awakening to find the equipment outgrown, even in dangerous condition, before you realize it. The remedy is likely to be expensive.

And responsibility for safety of operation must be considered. Try to see in your mind just how the operator will do his work and provide against mistakes. Picture the human element of the plant as well as the mechanical and electrical elements.

Answering the question, "Where are we likely to go from here?" forms no small part of the engineer's task whether in designing or planning for operation and imagination should be spurred by consciousness of such a question.

Off-duty time is up, though there is much interesting matter in the Bulletin which hasn't been touched. But let's look. These engineers, outstanding successes in the field, urge on us that, in our profession of service, we need to study engineering problems with broad vision of their human and financial relations, future developments and possibilities and adaptation to meet the wants of those served. That's some order, but they believe that it can be done and that joy of accomplishment is more than individual fame or wealth—though, goodness knows, we all need the money.

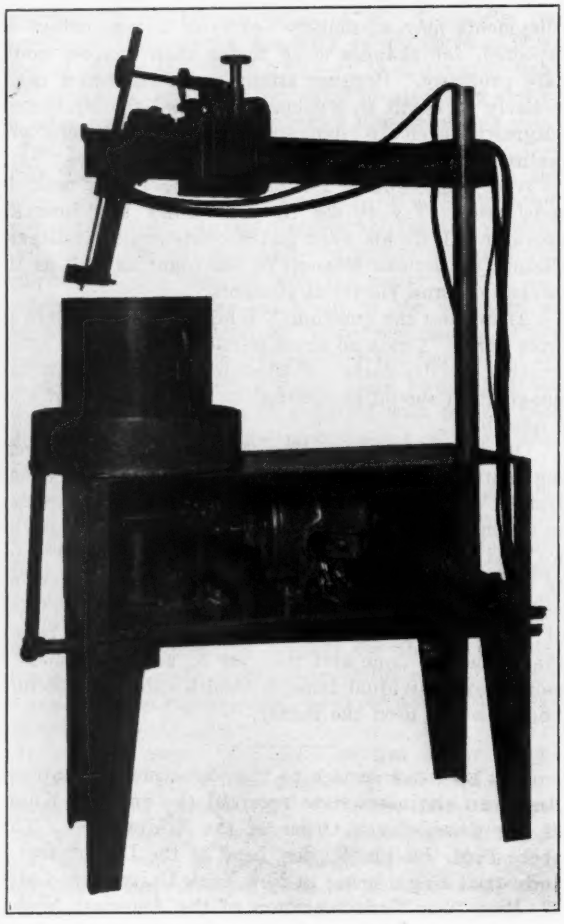
FOR EMINENT service to the Czechoslovak State, six American engineers have received the cross of Knight of the Czechoslovak Order of the White Lion. They are: Prof. Joseph W. Roe, head of the Department of Industrial Engineering in New York University; Calvin W. Rice, New York, secretary of the American Society of Mechanical Engineers; Alfred D. Flinn, New York, director of the Engineering Foundation; Lawrence W. Wallace, Washington, executive secretary of the American Engineering Council; H. S. Person, New York, managing director of the Taylor Society; Morris L. Cooke, industrial engineer of Philadelphia.

The Order was created "in accordance with the approval of the President of the Republic as decoration for citizens of foreign states in appreciation of their services rendered on behalf of the Czechoslovak State."

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New Motor Driven Welder Makes Welds Under Water

RAPID EXTENSION of the field of usefulness of electric arc welding has induced manufacturers of this type of equipment to bring out many new and interesting welding machines. The accompanying illustration showing a new carbon arc welding machine built by The Lincoln Electric Co., Cleveland, Ohio, is an example of one of the latest machines of this type.



ELECTRIC WELDING MACHINE WHICH MAKES WELDS UNDER WATER

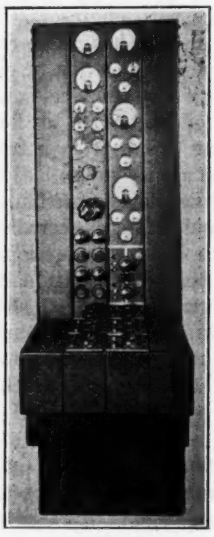
This machine will weld circular seams up to twelve inches in diameter and has as a particular feature the cooling tub around the revolving table which carries the piece being welded. The piece on which the welding is being done may be partially or totally immersed in water during the welding operation. Cooling water is in circulation in the tubs during operation.

Cooling arrangement used on this equipment was developed to meet the requirements when welding high grade alloy steels on which the heat disturbance due to application of welding heat must be reduced to a minimum. In the case of 12 per cent manganese steel, the welding may be done with the piece totally immersed in water and the arc submerged, the rapid quenching of the molten metal giving it the physical properties expected in such steel.

Frame and details of the machine are all made of welded steel construction, an excellent example of the rapidly growing tendency to use welded steel construction in place of gray iron castings.

Miniature Control Desk

IN THE ACCOMPANYING illustration is shown a new miniature control desk which has recently been developed by the Westinghouse Electric and Manufacturing Co. It consists essentially of standard equipment mounted in a compact form, and greatly facilitates the work of the operator.



FRONT VIEW OF NEW WESTINGHOUSE MINIATURE CONTROL BOARD

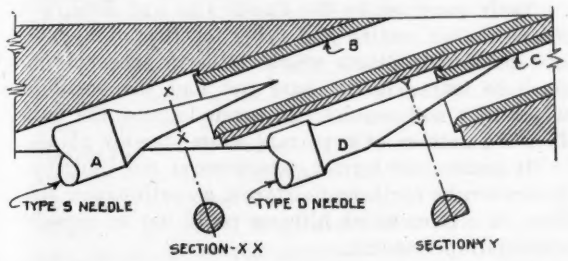
This desk is made of 1/8-in. stretcher level steel and is shipped in groups of four sections for convenience in handling but any number of units may be combined to make a complete board. The indicating wattmeters,

reactive factor meters and power factor meters are approximately 4 in. in diameter, and have identical movement with the larger and more frequently used switchboard instruments of 5½ in. and 7½ in. diameter. The ammeters and voltmeters are all high grade instruments although only approximately 2 in. in diameter and the meters are all of the flush type.

The accompanying illustration shows a front view of four sections with the two end sections left blank. The second section from the left is for the control of a large turbo-generator and includes all instrument and control equipment necessary for the generator including its direct-connected exciter, field circuits and regulator. It is also provided with controllers for the field switches so that the generator fields can be connected either to the direct connected exciter or to a spare exciter bus, all of this in the width of 6 in. All control switches are of the standard type, small, telephone type, indicating lamps used. The adjacent panel controls three feeders; each feeder is equipped with polyphase wattmeter, three ammeters, two control switches with red, green and white indicating lamps and synchronizing key interlocks. The control desk is completely equipped with miniature bus bars and cardholders for the main connections.

Universal Turbine Meets All Conditions

BY NOZZLING turbines to their maximum capacity with reamed straight nozzles and then providing each nozzle with a needle valve inserted into the mouth of the nozzle with its other end projecting through the



EITHER ONE OF TWO TYPES OF NEEDLE VALVES MAY BE USED

casing to the exterior where it is readily accessible for adjustment, The Standard Turbine Corp., Scio, N. Y., has developed a universal turbine.

All machines of the same frame size are exactly alike in every respect, and the nozzles are adjustable not only as to area, but also as to expansion ratio. By opening or closing off the greater or smaller number of nozzles, any horsepower can be obtained at a given speed up to the maximum range of the frame.

As the tip area of each nozzle is always constant and the throat area can be varied from 0 to the same size as the tip area, any expansion ratio, from 1 to infinity, can be obtained. The needle valve control permits changes in horsepower, speed, steam pressure, superheat or back pressure, always at the maximum efficiency obtainable on any turbine of the same wheel diameter, making the turbine usable for any horsepower from 5 to 350 hp. for any speed from the lowest up to 4000 r.p.m. and any superheat, steam pressure and back pressure within the range of the frame.

All small steam turbines are interchangeable regardless of the output in horsepower and steam conditions, allowing the turbine to be altered to meet new or unusual conditions with maximum efficiency and no expense, permitting the stocking of prime movers at distant points for resale, simplifying manufacture and shortening delivery dates.

Single Control Valve for Pressure Filters

TO LEAD WATER to and from a sand filter there are ordinarily three pipes, one for raw water, one for filtered water, and one for discharging washing water to waste. Valves are provided with cross connections so that the top of the filter can be connected either to receive water from the supply main or to discharge to waste, while the opening below the filter bed

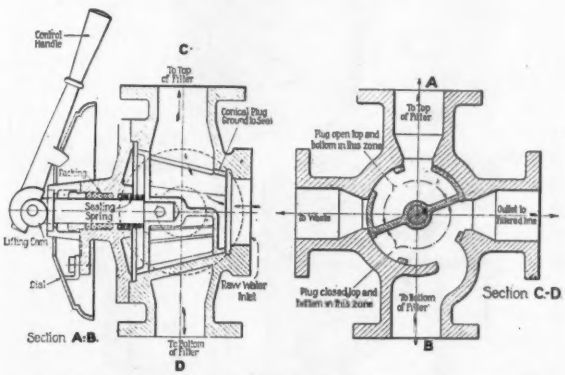


FIG. 1. AXIAL AND TRANSVERSE SECTIONS OF SINGLE CONTROL VALVE

is connected to discharge water to the filtered water line or to receive water for back-washing. In some cases filtered water is used for back-washing, and in others the raw, unfiltered water. If the latter, there is usually a connection from the outlet opening of the filter to waste, so that the unfiltered water remaining in the filter after back-washing can be allowed to flow to waste before connecting the discharge of the filter to the filtered water line. To carry out the three operations mentioned, namely, filtering, back-washing, and filtering to waste, requires five valves, one between the inlet opening and the raw water supply pipe, one between the inlet opening and the waste pipe, one between the outlet opening and the filtered water pipe, one between the outlet opening and the raw water pipe, and one between the outlet opening and the waste pipe. In a filter of any size these are all large gate valves; and they must be opened and closed in a somewhat complicated sequence.

All five valves, however, can be combined in one valve of the multiple-ported plug type, as shown by the accompanying illustrations, and this single valve can be fitted with an indexed dial so that an unskilled worker, who might be confused if required to manipulate five different valves in various combinations, can operate it correctly and rapidly.

The valve is held to seat by a seating spring, and

the pressure of the water on the unbalanced area of the conical plug further aids in holding it tight. An ordinary plug cock of the size required for a large filter would be hard to turn after it had become siezed in its seat because of expansion or contraction due to temperature changes, but in the valve shown herewith this difficulty is overcome by providing powerful means for lifting the valve from its seat before turning it. At each of the operating positions there is a slot in the dial into which a lug on the handle is pressed when the valve is seated.

When the control handle is pulled out, as it must be to rotate the valve, a cam upon the end of the handle lever attached to the valve spindle engages with the valve housing, exerting great force on the spindle, so that the conical plug is lifted from its seat. The plug can easily be rotated, regardless of the water pressure

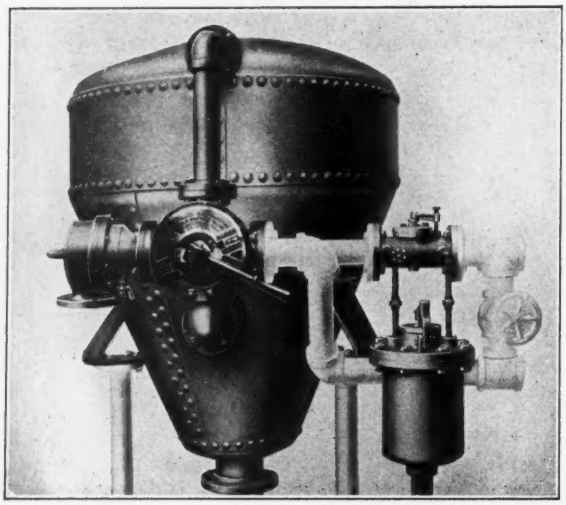


FIG. 2. SINGLE CONTROL VALVE, SHOWING FOUR OPERATING POSITIONS, AS APPLIED TO CONICAL SHELL PRESSURE FILTERS

and without scoring or wearing the seat. Should the valve or seat become scored by coarse sand or gravel, however, it can easily be reground by removing the lever, taking out the plug and applying oil and emery, or any good valve grinding compound and then replacing the plug and rotating the lever until the two surfaces are again smooth and tight.

This valve is being marketed by the Cochrane Corp., Philadelphia, Pa., which has developed it in connection with a line of pressure filters.

Lehigh Conducts Welding Symposium

SESSIONS OF the Welding Symposium held at Lehigh University, Bethlehem, Pennsylvania, Monday, April 4, were attended by members of the Lehigh Valley Engineers Club and practically the entire engineering student body. This meeting covered the matter of welding in construction and repair from many important angles. In an introductory discussion of the general subject, Professor Bradley Stoughton described the various processes of welding and following this the physical characteristics of joints made by all of the various welding processes were demonstrated by testing of actual specimens at the Fritz Laboratory.

This testing, which was done in the presence of the audience, involved stressing welding couples made by oxy-acetylene, electric arc, electric resistance and thermit processes to destruction and plotting the results of those tests.

An afternoon session was devoted to demonstrations of welding by the various commercial methods. At the evening session Professor F. P. McKibben, formerly of Lehigh University and Union College, defined the present status of welding. Messrs. Lang and Smith of the Lincoln Electric Company discussed the use of welding in structural steel work, and Mr. A. F. Jensen of the Hannan Engineering Works, Chicago, read a prepared paper in rebuttal, entitled "This Is the Age of Riveted Steel." The discussion which followed these papers brought out many facts which emphasized the dependability of a properly designed and properly executed weld made by any of the various methods in commercial use.

Pacific Gas and Electric Company Gets $60,000,000.00 Power Firms

ONE OF the largest hydroelectric power deals in the history of the State of California was consummated on April 27. Negotiations that have been pending for weeks between the Pacific Gas and Electric Co. and the Standard Gas and Electric Co., controlled by the Byllesby interests, resulted definitely in the acquisition by the Pacific Gas and Electric Co. of the Sierra and San Francisco Power Co., the Western States Gas and Electric Co. and the Coast Valleys Gas and Electric Co.

The properties in question are conservatively valued at more than $60,000,000.

Their purchase by the Pacific Gas and Electric Co. means the unification and tying together of hydroelectric generating plants which, hitherto operated under separate managements, have not had the possibilities which they now acquire. It means likewise the unification of a number of important steam standby plants.

It assures the former consumers of the Byllesby organization in northern California a continuance, for all time, of service which hitherto could not be considered absolutely permanent.

The following statement was issued by President W. E. Creed of the Pacific Gas and Electric Co.:

Subject to confirmation and approval by the Railroad Commission of California, the Pacific Gas and Electric Co. has concluded an arrangement with the Byllesby interests of Chicago for the acquisition by Pacific Gas and Electric Co. of the Sierra and San Francisco Power Co., the Western States Gas and Electric Co. and the Coast Valleys Gas and Electric Co., effective as of May 1, 1927. It is anticipated that J. J. O'Brien, president of H. M. Byllesby & Co. and of the Standard Gas and Electric Co., will be added to the Pacific board.

Insull Medals for Public Service Men

AT A MEETING of the Public Service of the National Electric Light Association in the Newark Terminal Building recently, six Public Service men received Insull Medals for having revived victims of electric shock by the prone pressure method of resuscitation. The

presentation was made by Colonel J. P. Jackson, manager of the personnel bureau of the New York Edison Co.

The men are: Edmund Hunnecutt, of Newark; George Farnkopf of Lyndhurst; Andrew Lorentz of Jersey City; Fred D. Berry of Paterson; Joseph A. Hurley of Trenton, and Willard Warner of Perth Amboy. Four are employes of Public Service Electric and Gas Co., and two of Public Service Production Co.

An address by Dr. Selby J. Day, former captain in the Czecho-Slovakia army, who described his experiences in Russia from 1917 to 1919 during the World War, and a showing of the Public Service safety education department's new motion picture, "What Price Recklessness," were other features of the meeting.

N. E. L. A. Plans Elaborate Program at Atlantic City

IF ADVANCE registration for hotel and transportation accommodations may be used as a basis for prediction, the coming fiftieth convention of the National Electric Light Association at Atlantic City, June 6—10, promises to be one of the largest in the history of the association. An elaborate and comprehensive program has been arranged which will deal with practically every phase of the industry, but the main theme will be the relation of the development of the electric light and power industry to the remarkable economic development in the United States during the last ten years.

Among the many prominent men and women who will discuss these matters are Dwight F. Davis, Secretary of War; M. H. Aylesworth, president of the National Broadcasting Co., Inc.; Gerard Swope, president of the National Electrical Manufacturers Association; J. F. Shaughnessy, president of the National Association of Railroad and Utilities Commissioners; Lovick P. Miles, publisher of the Commercial Appeal of Memphis, Tenn.; Albert C. Ritchie, Governor of the State of Maryland; B. C. Forbes of Forbes Magazine; M. L. Moon, a director of the American Farm Bureau Federation; Bancroft Gherardi, president of the American Institute of Electrical Engineers; Mrs. Mary King Sherman, president of the General Federation of Women's Clubs; D. F. Kelly, president of The Fair, Chicago; and William Green, president of the American Federation of Labor.

In connection with the convention will be held an unusually comprehensive exhibit of electrical equipment. One hundred and ninety-three manufacturers of electrical apparatus, appliances and equipment will display their products. In addition to practically all known electrical devices of commercial and laboratory use, all improvements and new discoveries of electrical science during the last 12 months will be displayed. Labor-saving and economy-making equipment for the home will have an important place in the exhibition.

Six general sessions of the convention will be held in the main auditorium of the Million Dollar Pier on the Atlantic City Boardwalk. These will be on the mornings of Tuesday, June 7, Wednesday, June 8, Thursday, June 9, and Friday, June 10, and the afternoons of Wednesday and Thursday. Parallel meetings of the four national sections, the accounting, commercial, engineering and public relations, will be held on Tuesday afternoon. The public policy meeting will be on Wednesday night. Radio hookups covering practically the whole country will be made for this event.

The president's reception and ball will be held Monday night, June 6th. The entertainment committee will have an unusually delightful program to fill in the time between business sessions. A famous New York orchestra will provide music for dancing every evening except on public policy night.

J. J. O'Brien of Chicago, president of the Byllesby Engineering and Management Corporation, is honorary chairman of the general convention committee, and R. F. Pack of Minneapolis, president of the association, is chairman.

Ample Supply of Soft Coal Assured

A SURVEY as to the possible bituminous coal production after April 1, in the event of a stoppage of mining in the union fields after that date, has just been completed by the Car Service Division of the American Railway Association in connection with its problems of car distribution.

Average weekly production of bituminous coal, according to the survey, of both union and non-union mines for the past four years for the period from April 1 to Sept. 30, amounted to 9,401,000 t. This included 1926 when there was a heavy export movement of bituminous coal due to the strike of British miners.

Bituminous coal actually produced by mines operated by non-union labor for the week ended Dec. 4, 1926, amounted to 8,261,852 t. During that week, non-union mines having a car rating per week equal to 1,502,316 t. were not in operation. With those mines in operation, the potential production would be 9,764,168 t., or a production of 363,168 t. in excess of the total weekly average for the past four years.

The survey of the Car Service Division shows that the car supply and transportation service will be wholly adequate to take care of any output that may be produced.

News Notes

JENKINS BROS., New York City, announces the appointment of Joseph E. Hodgkins as manager and Anthony D. Weber as assistant manager of its New England branch with headquarters at 524-530 Atlantic Ave., Boston.

It also announces that after almost 40 yr. of service with Jenkins Bros., of which 30 yr. has been passed as manager of the New England branch, John D. Stiles is passing from the active to the retired list.

YEOMANS BROTHERS CO., Chicago, announces the appointment of five new representatives to handle the complete Yeomans line of ejectors and pumps. These representatives are as follows: Texas Engineering Co., 925 Electric Bldg., Houston, Tex.; Dillard Engineering Co., 612 Construction Industries Bldg., Dallas, Tex.; Heating & Ventilating Equipment Co., Builders & Traders Exchange, Grand Rapids, Mich.; A. R. Amos, Jr., 1014 Harrison Bldg., Philadelphia, Pa., and C. L. Knehr, Hubbell Bldg., Des Moines, Ia.

BROWN INSTRUMENT CO. announces the opening on April 1 of a Cincinnati branch office located in the First National Bank Bldg., Cincinnati, Ohio. J. R. Green is the district manager.

EDGE MOOR IRON CO., Edge Moor, Dela., announces that on April 28 the New York sales office with J. F. Glenn and H. M. Lodge in charge and The Waste Heat Consulting Engineering office in charge of F. Falla were combined and are now located in the Graybar Bldg., Lexington Ave. and 43rd St., New York City.

WM. H. BAKER and C. G. Spencer announce the organization of the firm of Baker and Spencer, Inc., for the general practice of engineering and construction at 117 Liberty St., New York City. Mr. Baker acted for ten years in managerial capacities for the Atlas Portland Cement Co., two years as vice president and general manager of the Hardinge Co., three years as president of the Quigley Fuel Systems, Inc., two years as president of the Acme Cement Corporation, and one year, until his resignation to organize this firm, as vice president of the North American Cement Corporation. Mr. Spencer has been engaged in the design, construction and operation of projects, including power plants for industrials and public utilities, during nine years with Westinghouse, Church, Kerr & Co., three years with the Toronto Power Co., two years with the Chile Exploration Co. in South America, two years in the United States army, two years with the American Sugar Refining Co. and five years with McClellan & Junkersfeld, Inc., of New York.

HOMESTEAD VALVE MFG. CO., Homestead, Pa., announces the appointment of Ziegler-White Co., 155 Second St., San Francisco, Calif., as its exclusive representative in that territory. The Ziegler-White Co. will carry a full line of Homestead products.

CYRUS A. LELAND, JR., has been appointed to succeed the late M. G. Linn as Vice President and General Manager of the Des Moines Electric Light Co. and the Iowa Light & Power Co. at Des Moines, Ia.

THE BOILER ENGINEERING CO., Newark, N. J., has recently secured Rittlemeyer & Co. with offices in the Bona-Allen Bldg., Atlanta, Ga., as representative in that territory.

THE DETROIT STOKER CO., Detroit, Mich., announces the appointment of A. Kastello as district sales representative for eastern Canada and Montreal, Quebec, territories with headquarters in the new Birks Bldg., Montreal. Detroit stokers for distribution throughout Canada are manufactured at St. Catherine's, Ont.

THE POWER SPECIALTY CO. announces the opening of an office in Atlanta, Ga., located in the Bona Allen Bldg., with J. W. Lea in charge. This office will serve the states of South Carolina, Georgia, Florida, Alabama and most of Tennessee. It is the intention of the company to keep in close contact with the development in these states by giving engineering estimates and advice, as well as furnishing drawings made for proposed installations in accordance with the usual practice.

AT THE ANNUAL meeting of The Timken Roller Bearing Co., Canton, Ohio, on April 19, all the present officers were re-elected for another year. H. H. Timken is president; W. R. Timken, John G. Obermier, Marcus T. Lothrop, H. J. Porter and T. V. Buckwalter are vice presidents; J. F. Strough is secretary and treasurer, and W. A. Brooks is assistant secretary. Directors are H. H. Timken, W. R. Timken, Marcus T. Lothrop, John G. Obermier and J. F. Strough.

H. R. CONDON, formerly an officer of the Pennsylvania R. R. Co., has been elected general manager of the American Mond Nickel Co. and took charge of this company on April 1 with headquarters in the Century Bldg., Pittsburgh, Pa.

CELITE PRODUCTS CO., Los Angeles, Calif., announces the appointment of Col. H. C. Boyden as lecturer on recent investigations carried on for the determination of the workability of different concrete mixtures and the effect which this factor has upon the quality, cost and appearance of concrete for structures of all kinds. His talks will emphasize the importance of avoiding excess water and will include discussions of other important and interesting points in connection with concrete design and construction. The company is at the present time arranging a series of lectures to be given by Col. Boyden in cities throughout the United States and Canada.

ANNOUNCEMENT has been made that the Cleveland district offices of Combustion Engineering Corp., Ladd Water Tube Boiler Co. and Heine Boiler Co. have been consolidated and will be located in the Guardian Bldg., Cleveland, O. Frank Henderson will have charge of the Cleveland district offices of these three associated companies.

THE CARBORUNDUM CO., Niagara Falls, N. Y., announces that its refractory division at Perth Amboy, N. J., has completed a motion picture telling the story of the manufacture of Carborundum refractories and the various uses for them. This film can be secured by applying to the Carborundum Co., refractory division, Perth Amboy, N. J. Arrangements can be made for a speaker to present the film and to supplement its story with added information on the refractory problem in general.

KNOWN AS THE Bonney No. R Set, a new socket wrench set has been placed on the market by Bonney Forge & Tool Works, Allentown, Pa. This is a complete chrome vanadium set, even the handles being of this material. The set consists of 10 chrome vanadium hexagon sockets from $\frac{7}{16}$ to $\frac{7}{8}$ in. inclusive and the following chrome vanadium handles: solid offset handle, offset ratchet handle, sliding T handle, solid T handle 6 in. long, solid T handle 12 in. long, 2 brace or speeder type handles (one long and one short) a 5-in. extension and 10-in. extension and universal joint. This entire outfit is neatly packed in a handsome enameled metal carrying case with leather handle.

THE WALTER G. HEACOCK CO., Cleveland, Ohio, has opened offices at 400 Penobscot Bldg., Detroit, Mich., and 30 Euclid Arcade, Cleveland, Ohio, to represent the following manufacturers in the Michigan-Ohio field: N. C. Cotabish, Indestructible Water Meter Discs; Precision Thermometer & Instrument Co.; The Auburn Stoker Co.; Power Plant Equipment Co., manufacturers of superheaters and spray pond equipment; United Electric Co., manufacturer of Tueck stationary vacuum cleaners.

THE BROWN INSTRUMENT CO., Philadelphia, Pa., announces the opening of a Midwestern repair and service station under the supervision of factory-trained instrument mechanics. This service relieves customers of the

necessity of shipping to the factory for repairs and repair parts. This station will also handle charts, thermocouples, protecting tubes, extension leads, instruments of standard ranges and instrument parts from stock.

THE NORTHEASTERN PIPING & Construction Corp. of North Tonawanda, N. Y., has recently secured several important contracts for pipe work in connection with heating systems. At Akron, Ohio, the Akron Steam Heat Co., which will be operated by the Northern Ohio Power & Light Co., will install a complete underground steam distribution system to serve the business section of that city. In Philadelphia, the Philadelphia Electric Co. has contracted for the installation of the first step of a large underground steam distribution system which will serve sections of the business section with district steam heating. At Cedar Rapids, the Iowa Railway & Light Co. will install considerable extension to its underground steam distribution system which serves the downtown district of Cedar Rapids. At Johnstown, Pa., the Pennsylvania Public Service Corp. of Johnstown, Pa., has planned the installation of considerable underground steam main work in connection with its district heating system.

THE PHILADELPHIA district offices of Combustion Engineering Corporation, Heine Boiler Co. and Ladd Water Tube Boiler Co. have been consolidated at 807 Bankers Trust Building, Philadelphia, Pa.

C. R. AHLQUIST, chief engineer of The Gates Rubber Co., Denver, Colo., has a corps of engineers now working on designs and specifications for a power plant to supply all power and light required by the company's group of factory buildings in South Denver. The plans call for the use of bleeder turbines operating at 350-lb. steam pressure.

LINCOLN ELECTRIC CO. of Cleveland, Ohio, has appointed Royal D. Malm as western district sales manager, with headquarters at Chicago.

Mr. Malm is an engineering graduate from Case School of Applied Science, Cleveland, Ohio, class of 1912. For four years after leaving school he was engaged in construction engineering and then became identified with the Elyria Iron & Steel Co., later going with the Standard Welding division of the Standard Parts Corp. as general superintendent. For the past year Mr. Malm has had charge of Lincoln sales in the automotive industries with headquarters in Detroit.

MESSRS. G. E. MILLNER & CO., LTD., Parliament Mansions, Victoria St., London, announces that it has secured control of the patent rights in the Pitman deflector regulator for automatic speed control of impulse water turbines and is prepared to grant general or exclusive licenses in the United States, the United Kingdom, Canada, Switzerland, France and other European countries.

The inventor of the device, Percy Pitman, states that it is to be fitted to some new 21,000-b.hp. units now being planned to operate under a head of 2800 ft.

THE GENERAL GAS & ELECTRIC CORP., New York, operating the Broad River Power Co., Columbia, S. C., and other utilities in that section, has authorized plans for a new hydro-electric plant on the Saluda River, about 10 mi. from Columbia. This work will include the construction of a power dam 188 ft. high and 8000 ft. long and a generating station with an initial output of about 200,000 hp. Murray & Flood, New York City, have been retained as consulting engineers for the project which will be carried out in the name of the Lexington Water Power Co. Most of the construction will be handled by The W. S. Barstow Management Association, affiliated with the General Gas & Electric Corp.

THE MUSEUMS of Peaceful Arts was opened on Wednesday evening, April 20, by a dinner and appropriate program arranged by the American members of The Newcomen Society. This museum occupies temporary headquarters at the Scientific American Bldg., 24 West 40th St., New York City, where a start has been made in organizing an industrial technical museum for the City of New York. The Newcomen Society is organized for the study of history and technology and has its headquarters in London, England, but it has an active group in America which meets annually for presentation of papers and discussion of historical topics.

THE NEW YORK OFFICE of Wm. B. Scaife & Sons Co. of Pittsburgh, Pa., has been moved from its location at 26 Cortlandt St., where it has been for 20 yr. The new office is in the Architects Building at 101 Park Ave. Metropolitan district sales of the company's various products are handled from this office by the manager, H. F. Reynolds.

ANNOUNCEMENT IS MADE of the formation of a new Canadian company, the Canadian Power Specialty Co., which has purchased the plant of the former Engineering & Machine Works of Canada, Ltd., at St. Catherines, Ont. G. R. Cottrelle, of the Canadian Bank of Commerce, Toronto, and G. B. Greene, of the General Supply Co. of Canada, Ltd., Ottawa, were chiefly responsible for the formation of the new company and for arrangements under which it is to manufacture and sell Foster superheaters, economizers, water backs, Aero unit coal pulverizers and other Foster power plant equipment in the Dominion.

THE MUSCATINE MUNICIPAL ELECTRIC LIGHT CO., Muscatine, Ia., has just completed the installation of a 1875-kv.a. Allis-Chalmers turbine and is now installing a new 600-hp. Murray boiler. This is to be fired by coal burned on Taylor stokers and is designed for 150 deg. of superheat. It will be in operation by May 1. The present equipment of the plant consists of two 940-kv.a. Westinghouse turbines and 2300-hp. Heine boilers fired by Taylor stokers. J. E. Tuttle, superintendent, and E. Carlson, chief engineer, have been in charge of the installation of the new equipment.

WORK HAS BEEN STARTED on the conversion of the Fort Edward mill of the International Paper Co. into a specialty paper mill. It is expected that the new plant will be in operation in less than a year, employing about 500 men and women. The Fort Edward mill is on the Hudson River about 500 mi. above Albany. Plans include the redevelopment of the hydraulic plant, also the steam plant and sulphite mill and the use of the barge canal terminal at Fort Edward.

FLORIDA POWER CORP. has been organized by the National Public Service Corp., an interest of A. E. Fitkin

& Co., to take over and consolidate the company of the same name, the Pinellas County Power Co. and the Central Power & Light Co., operating on the west coast of Florida.

AT A MEETING held April 1 in Chicago, the directors of the Power Transmission Ass'n decided to create a board of advisory engineers from among the leading industrial and operating engineers of the country. As chairman of this board the directors have appointed William Staniar, building and transmission engineer of the Du Pont Company. It is the hope of the Association to secure on this board with Mr. Staniar representative engineers connected with various industries in the country who are specifiers and users of mechanical transmission appurtenances.

It will be the function of this board to assist in solving the problems that daily confront industry in the mechanical transmission of power; also to advise, when requested, as to the economical and efficient transmission layouts for new installations and the simplifying and modernizing of existing arrangements.

TWO CONTRACTS COVERING four 33,333-kv.a. transformers and seven 25,000-kv.a. transformers, respectively, for the Southern California Edison Co. have been placed with the Westinghouse Electric and Manufacturing Co. All of these units are to be single phase, self cooled-air blast, and for use on the 220,000-v. system of the Southern California Edison Co., one of the oldest operating companies in the 220,000-v. field.

These transformers are equipped with cooling radiators enabling them to carry 60 per cent of the maximum capacity. Each unit will also be equipped with its own individual blower and motor controlled by oil temperature to increase the efficiency of the radiators. The transformers are to be built with the shell form of construction and will be equipped with inertaire apparatus for protection of the transformers and preservation of the oil.

The 33,333-kv.a. larger transformers go to the new Sunset steam plant of the Southern California Edison Co., for which Stone & Webster, Inc., of Boston has acted as consulting engineers. The seven 25,000-kv.a. transformers go to the Lighthipe substation and will be used to connect 220,000-v. and 60,000-v. transmission systems. They are similar in construction to the four larger units.

Catalog Notes

CROUSE-HINDS CO., Syracuse, N. Y., is issuing a large illustrated folder showing various types of the new Obround condulets.

W. H. NICHOLSON & CO., Wilkes-Barre, Pa., has issued Bulletin No. 227 entitled "Moisture—Oil—Dirt in Compressed Air and Nicholson Devices for Removing Them."

CHICAGO CHEMICAL CO., Chicago, Ill., in bulletin 9A, just issued, publishes a discussion of a flexible and scientific method of treating feed water in the boiler by A. E. Warner, sales manager of the company. This article discusses first the trouble caused by improper feed water, then the subject of blow down control, general water treatment and finally, the details of using K. W. S. Sodium Aluminate and the discussion of what it accomplishes and what it costs. In another bulletin, No. 12A, "How to Increase the Efficiency of Lime and Soda Ash Softening Plants," by F. H. Thorne of the company, discussion is given of the way in which K. W. S. Sodium Aluminate can be used in conjunction with this method of treatment.

AUTOMATIC ARC WELDING is discussed in a 16-page bulletin just issued by General Electric Co., Schenectady, N. Y. The bulletin describes various types of automatic welders for oil valves, straight seams, tanks, tubes and similar equipment.

SCHUTTE & KOERTING CO., Philadelphia, Pa., in Bulletin No. 2-M describes and illustrates water jet eductors and water operated cesspool pumps, sand washers, and so on. The water jet eductors are liquid pumps designed on the jet principle and using liquid under pressure as the operating medium. They are designed for pumping water or other liquids in cases where durability, low cost and simplicity of manipulation are of primary importance. They are adapted to many services in power plants, industrial processes and general construction work. They may also be applied as agitators and as ejectors for handling material containing solid matter. In the latter case the design is modified somewhat to allow passage of this solid matter through the pump.

IN THE MARCH issue of Bacharach News, published by Bacharach Industrial Instrument Co., is given a detailed discussion of the Maihak indicator for oil engines and of the general principles and construction of the Bacharach magnifying manometers.

GRINNELL CO., Providence, R. I., in a 90-page well illustrated bulletin describes its various types of swivel hangers, clips, brackets, pipe rolls, adjustable pipe stands and other equipment for supporting pipe. Price lists and dimensions of all equipment are a valuable feature of the catalog.

ROLLER-SMITH CO., New York City, has issued supplement No. 1 to bulletin No. 550 covering the new type FR line of relays, of which the principal application is in connection with contact making instruments, meters and similar devices. Supplement No. 1 to bulletin No. 100 discusses several types of instruments used principally in signal system and automatic train control work.

ENGINEERING FOUNDATION, Engineering Societies Bldg., New York City, has just issued Publication No. 12, its annual report for the year ending February 17, 1927. The report contains portraits of the Founder Societies' presidents, a discussion of the origin and functions of the Foundation, a review of the year's activities, various financial statements, lists of officers and members and some particularly interesting photographs of the work being carried on at the Stevenson Creek experimental arch dam under the auspices of the Engineering Foundation.

THE MAGNOLIA METAL BEARING BOOK, second edition, has just been issued by Magnolia Metal Co., New York City. This contains a discussion of Magnolia antifriction metal, together with simple, practical instructions for the making of lined bearings for economical service. Discussion of the characteristics of the metal is given, together with many illustrations of its application for various services.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Prejudices Never Pay Profits

Playing favorites has cost kings their empires, politicians their offices, business men their establishments and all of us more or less of our incomes.

Prejudice precludes correct judgment, large dividends and profitable living. Prejudice is the offspring of ignorance.

Let the facts be known and prejudice must dissolve before them. Only without prejudice can any great constructive work be accomplished.

Of all the great modern industrial developments power generation is singularly the industry that must and shall forever be conducted without prejudice.

Throughout more than a century and a half mechanical power continued a slow course of development in which the main purpose was to produce the needed power. Power plants and the men who operated them were little considered among the many factors of industry and business.

Often engineers were forced to buy where others dictated. Frequently power plant machinery, equipment and supplies were the butt of favoritism. Often prejudice sapped the hearts of the men who knew and the useful energy from the fuel supply.

Then, almost overnight, all industries discovered that efficient mechanical power must be the basis of all industrial existence. Production, sales, profits, dividends and new financing became largely dependent on the use of more power at less cost.

Immediately these men who could provide this basic factor of civilization were forced to the forefront, and then followed the past decade in which coal consumption was forced downward and ever downward from where eight or more pounds were used per kilowatt hour to where little more than a pound generates a kilowatt hour.

In this period the annual expenditure for power plants and their equipment has steadily increased, each year by many millions of dollars, until the billion dollar annual market has long been passed.

All factors involved in the substantial upbuilding of an industry have been served by the power plant industry to a degree never excelled if ever equalled.

Users have light and power more abundantly supplied, more generally distributed, and at a cost that is little more than half that of other commodities as compared with prices before the war.

Modern power plants of public and private companies are earning excellent dividends on their investments. The general public is profiting in a thousand ways in which power serves everyone indirectly.

Sweeping onward to still higher achievements, power plant men are planning new plants, for the construction and equipment of which new capital is available wherever opportunity offers. For in the power plant field the double security of lower production cost and increasing demand for the product continues.

Progress without prejudice is the mainspring of this record of prosperity and the surety of its continuance.

From the continuous flow of information, the record of facts, the figures of results, interpreted and passed on through these pages, progress continues.

Manufacturers have no secrets in these days. They are ready to give you the helpful information they have obtained through vast and costly experience. They are searching for the solution of the engineering problems that are ever changing.

Operating men who advance with this great onward movement of their profession, give of their experience and take from the experience of others with their minds open and without prejudice.

In the advertising pages of this magazine, there are constantly being published the experiences of men and their achievements without fear or prejudice.

Prejudice, misconception and lack of information creep in, even in engineering as they do in neighborhood, national and world affairs, wherever free interchange of information and familiar contact between men is broken.

The industry of power generation will continue to meet the greater opportunities of the future. And the participation in it of each person and each business depends on the maintenance of the dissemination of information.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Binks Spray Equip. Co., Chicago, Ill.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner Governor Co., The, Quincy, Ill.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa.
Sullivan Machy. Co., Chicago.
Yeomans Bros. Co., Chicago.

AIR WASHERS.
Buffalo Forge Co., Buffalo, N. Y.
New York Blower Co., Chicago.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland.
Wright-Austin Co., Detroit.

ANTI-CORROSIVE COATINGS.
Dampney Co. of Amer., Boston.

ARCHES, BOILER AND COMBUSTION.
Brady Conveyors Corp., Chicago.
Burke Engineering Co., Holland, Mich.
Carborundum Co., Perth Amboy, N. J.
Detrick Co., M. H., Chicago.
Girtanner Engrg. Corp., N. Y.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., M. A., Indianapolis.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., Phila.
Conveyors Corp. of Amer., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., N. Y.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Philadelphia.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., N. Y.
Link-Belt Company, Chicago.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

ASH TANKS.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago.

BABBITT METAL.
Magnolia Metal Co., New York.

BAROMETERS.
Taylor Inst. Co.'s, Rochester, N. Y.

BEARING METAL.
Magnolia Metal Co., New York.

BEARINGS.
National Tube Co., Pittsburgh.

BELT CONVEYORS.
Jeffrey Mfg. Co., Columbus.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELTING.
Crandall Pkg., Palmyra, N. Y.
New York Belting & P'k'g Co., New York.
Quaker City Rubber Co., Phila.
United States Rubber Co., N. Y.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE.
Air-Preheater Corp., New York.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
New York Blower Co., Chicago.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT.
McClave-Brooks Co., Scranton.
New York Blower Co., Chicago.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, PORTABLE.
Sturtevant Co., B. F., Hyde Park, Mass.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy, N. J.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
Insulating Products Corp., N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.

BOILER SETTINGS.
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy, N. J.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N.Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 172

BLOWERS, PRESSURE.
Carling Turbine Blower Co., Worcester, Mass.

BLOWERS, PULVERIZED COAL.
Buffalo Forge Co., Buffalo.

BLOWERS, STEAM.
Schutte & Koerting Co., Phila.

BLOWERS, TUBE.
Diamond Power Spec. Corp., Detroit, Mich.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Vulcan Soot Cleaner Co., Du Bois, Pa.

BLOWERS, TURBINE.
Carling Turbine Blower Co., Worcester, Mass.
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Boiler Engr'g Co., Newark, N. J.
Engineer Co., The, New York.
McLeod & Henry Co., Troy, N.Y.
Quigley Furnace Spec. Co., N. Y.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER CASING.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.

BOILER COATINGS.
Dampney Co. of Amer., Boston.

BOILER COMPOUND.
Botfield Refractories Co., Phila.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N.Y.
Paige & Jones Chem. Co., N. Y.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER ENGINEERS.
Boiler Engr'g Co., Newark, N. J.

BOILER FEED WATER, PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chem. Co., N. Y.
Permutit Co., New York, N. Y.

BOILER FRONTS.
McLeod & Henry Co., Troy, N.Y.
Rust Engrg. Co., Pittsburgh.
Walsh & Weidner Boiler Co., Chattanooga, Tenn.
Walsh Fire Clay Products Co., St. Louis, Mo.

BOILER TUBE CLEANERS.
General Spec. Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Murray Iron Works Co., Burlington, Iowa.
National Tube Co., Pittsburgh.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Phila.
Insulating Products Corp., New York, N. Y.

BOILERS.
Ames Iron Wks., Oswego, N. Y.
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Connelly Boiler Co., The D., Cleveland, O.
Edge Moor Iron Co., Edge Moor, Dela.
Erie City Iron Works, Erie.
Heine Boiler Co., St. Louis, Mo.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Springfield Boiler Co., Springfield, Ill.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.
Wickes Boiler Co., Saginaw.

BRICKS, FURNACE LINING.
Norton Co., Worcester, Mass.

BREECHINGS.
Connery & Co., Inc., Phila.
Littleford Bros., Cincinnati.

BRUSHES, DYNAMO AND MOTOR.
Calebaugh Self-Lubricating Carbon Co., Inc., Philadelphia.
Dixon Crucible Co., Jos., Jersey City, N. J.
LeValley Vitae Carbon Brush Co., New York, N. Y.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Brady Conveyors Corp., Chicago.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

BUCKETS, COAL HANDLING.
Jeffrey Mfg. Co., Columbus, O.

CAR DUMPERS.
Wellman - Seaver - Morgan Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET.
Jeffrey Mfg. Co., Columbus, O.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Erie City Iron Wks., Erie.
Fuller Lehigh Co., Fullerton, Pa.
Girtanner Engrg. Corp., N. Y.
Hills-McCanna Co., Chicago.
Neemes Fdry., Inc., Troy, N. Y.

CEMENT, ASBESTOS.
New York Belting & P'k'g Co., New York.

CEMENT, FURNACE.
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy, N. J.
Harbison - Walker Refractories Co., Pittsburgh.
Insulating Products Corp., N. Y.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.
Walsh Fire Clay Products Co., St. Louis, Mo.

CEMENT GUNS.
Cement-Gun Co., Inc., Allentown, Pa.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Phila.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Johns-Manville Corp., New York.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Quigley Furnace Spec., Co., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.

CEMENT, INSULATING.
Insulating Products Corp., N. Y.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHEMICALS, WATER TREATING.
Chicago Chemical Co., Chicago.

CHIMNEYS.
American Chimney Corp., N. Y.
Rust Engrg. Co., Pittsburgh.
Springfield Boiler Co., Springfield, Ill.

CIRCUIT BREAKERS.
Cutter Co., The, Philadelphia.

CLEANERS, BOILER TUBE.
General Spec. Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

CLEANING COMPOUND.
Dearborn Chem. Co., Chicago.